Improving Air Quality Through Local Plans and Programs

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Prepared by
The Association of Bay Area Governments
The Bay Area Air Quality Management District

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INTRODUCTION TO APPENDICES

These appendices contain detailed information for use by planning staff of cities and counties in drafting air quality elements, policies, and programs. They are meant to complement and supplement the Guidebook text, *Improving Air Quality Through Local Plans And Programs.* Appendices A and B provide the major rationale for air quality management. Appendix A (Air Pollutant Sources and Effects) describes the deleterious effects of air pollution on health and other aspects of the quality of life. Appendix B (Air Quality Laws, Programs and Standards) discusses the legal framework for public intervention in the management of air quality.

The next set of appendices provides information regarding local problems within the regional context. Appendix C (Air Pollution — Status, Problems and Trends) explains air quality problems and trends on the local, as well as regional level. Appendix D (Climate, Topography and Air Pollution Potential) describes natural conditions that contribute to air quality problems.

The next two appendices suggest planning measures for protection of air quality on the local level. Appendix E (Local Planning Strategies) presents community and regional planning principles, development strategies, and implementation programs; it includes a matrix which matches selected recommended measures to the community conditions for which they are appropriate. Appendix F presents recommendations about street layout and design, connections between community activity centers, and site design; it includes a checklist for use in reviewing workplace and residential projects. Appendix F has been published separately by the Association of Bay Area Governments (ABAG) and the Bay Area Air Quality Management District (Air District); it is titled *DESIGN STRATEGIES for encouraging alternatives to auto use through local development review.* This publication can be obtained from ABAG.

Appendix G (Local Air Quality Planning Procedures) suggests alternative procedures for formulating local air quality policies, plans and programs. Appendix H (Benefits and Costs of Local Air Quality Programs) outlines some of the key benefits to communities — as well as to the region — from local involvement in the air quality management process.

The appendices conclude with a Glossary (of air quality planning terms), a Bibliography (of reference information on the citations in the appendices and additional publications of use to local planners for integrating air quality concerns into local plans and programs), and a list of Resources (staff who contributed to the appendices and whom to call for additional information or to answer questions).

The information in this issue of the appendices is current as of the end of September, 1994. Supplements and/or replacement pages will be available when revisions are necessary.

APPENDIX A: AIR POLLUTANT SOURCES AND EFFECTS

This appendix discusses the harmful effects of air contaminants on health and other qualities of life and the environment. Sources of pollution are described. Tables at the end of this appendix list types of stationary sources of criteria pollutants, air toxics and airborne nuisances.

Criteria Contaminants — Health Effects and Sources

Criteria contaminants are those air pollutants for which ambient air quality standards have been set by the United States Environmental Protection Agency or the California Air Resources Board. Most of the criteria contaminants are generated to a large degree by motor vehicles as well as by industry and other stationary sources. The Guidebook text (page 5) presents a summary table of sources and effects; Appendix C provides further detail regarding the sources of each criteria contaminant in each county of the Bay Area.

Carbon Monoxide (CO) is an odorless, colorless gas. It is formed by the incomplete combustion of fuels. The single largest source of CO is the motor vehicle. Emissions are highest when a vehicle is idling or moving at low speeds. New findings indicate that CO emissions per mile are lowest at about 45 mph for the average light-duty motor vehicle in the Bay Area and begin to increase again at higher speeds.

When inhaled at high concentrations, CO lowers the amount of oxygen in the blood, displacing it by raising carboxyl hemoglobin levels. CO can cause headaches, dizziness, unconsciousness, and even death. It can also aggravate cardiovascular disease.

Ozone (O_3), or smog, is not emitted directly into the environment, but is formed in the atmosphere by complex chemical reactions between oxides of nitrogen and reactive organic compounds (reactive hydrocarbons) in the presence of sunlight. Ozone formation is greatest on warm, windless, sunny days. The main sources of nitrogen oxides (NO_x) and reactive hydrocarbons (HC), often referred to as ozone precursors, are combustion processes (including motor vehicle engines) and the evaporation of solvents, paints and fuels. As with CO, automobiles are the single largest source of ozone precursors in the Bay Area. Reactive hydrocarbon emissions are highest at low vehicle speeds and decline as speeds increase up to about 50 mph. Nitrogen oxide emissions follow a different curve; emissions decrease as the vehicle approaches 30 mph and then begin to increase with increasing speeds.

Ozone levels usually build up during the day and peak in the afternoon hours. Ozone can irritate the eyes and aggravate respiratory disease, speed up the aging of lung tissue, and reduce resistance to colds and other infections. It can also damage plants and trees and materials such as rubber and fabrics (see Non-Health Effects section below).

Nitrogen dioxide (NO_2) is a reddish brown gas that is a by-product of combustion processes. Automobiles and industrial operations are the main sources of NO_2. Aside from its contribution to ozone formation, nitrogen dioxide can increase the risk of acute and chronic respiratory disease and reduce visibility. NO_2 may be visible on high pollution days, especially in conjunction with high ozone levels.

Sulfur dioxide (SO_2) is a colorless gas with a strong odor and potential to damage materials; it can have health effects at high concentrations. It is produced by the combustion of sulfur-containing fuels, such as oil and coal. Sulfur dioxide can irritate lung tissue and increase the risk of acute and chronic respiratory disease.

PM_{10} (Particulate matter 10 microns or less in diameter) refers to a wide range of solid or liquid particles in the atmosphere, including smoke, dust, aerosols, and metallic oxides. Some particulate matter, such as pollen, is naturally occurring; but in the Bay Area most particulate matter is caused by combustion, factories, construction, grading, demolition, agricultural activities and motor vehicles. Extended exposure to particulate matter can increase the risk of chronic respiratory disease. PM_{10} is of concern because it bypasses the body's natural filtration system more easily than larger particles, and can lodge deep in the lungs. Thus, the U.S. EPA and the State of California have revised their standards for particulate matter to apply only to these fine particles.

Again, as with CO and ozone precursors, motor vehicles constitute the single largest source of PM_{10} in the Bay Area, based on the best available data. Motor vehicles produce particulates through direct tailpipe emissions of particulate; direct emissions of nitrogen oxides, which become particulate (ammonium nitrate) in the atmosphere; and the kicking up of road dust by tires. Motor vehicles are currently responsible for about half of Bay Area particulates.

Fine particulate pollution is an example of a problem that may increase in the Bay Area as motor vehicle use increases, though there may also be short-term decreases. For instance, when construction activity is reduced during a recession, direct construction dust is reduced; therefore there is less dirt spilled on roads via trucks and other mobile equipment, reducing the amount of dust that can be resuspended by the tires of passing motor vehicles. But, as seen in the graph of Bay Area Emissions Inventory Projections (Figure C.2.d in Appendix C), total PM_{10} emissions are expected to increase and the proportion attributable to motor vehicles will also increase. Resuspended road dust has not been reduced by improvements in motor vehicle air pollution controls; road dust will, in fact, continue to increase unless there is a reduction in motor vehicle use and adoption of dust control measures. Dust control measures may be needed at construction sites, unpaved roads and parking lots, agricultural and other area sources that emit dust directly into the ambient air and/or convey mud and dirt to roadways.

Wood burning in fireplaces and stoves is another large source of fine particulates. The Air District and consultants have recently analyzed the results of a study of the sources of particulates at two monitoring sites in San Jose. In and near downtown San Jose — and perhaps in many other parts of the Bay Area — wood smoke can average about 40% of the particulate mix during the winter months; wood burning alone may cause exceedances of California's particulate standard (Chow, 1994).

Among the criteria pollutants that the Air District regulates, particulates appear to represent the most serious overall health hazard. Studies in a number of cities have demonstrated statistically significant correlations between daily and average annual particulate levels and mortality. According to one estimate, elevated particulate levels contribute to the death of roughly 200 people annually in the Bay Area (Fairley, 1990). Other studies, which include findings from the Bay Area, yield higher estimates of mortality — 300 to 500 deaths per year in the Bay Area — based on a one percent increase in mortality per 10 micrograms per cubic meter increase in PM_{10} levels (Ostro, 1993 and Dockery & Pope, 1994). High levels of particulates have also been known to exacerbate chronic respiratory ailments, such as bronchitis and asthma and have been associated with increased emergency room visits and hospital admissions.

Toxic Air Contaminants

In addition to the *criteria pollutants* listed above, another group of pollutants, commonly referred to as toxic air contaminants or hazardous air pollutants, has received increasing scrutiny in recent years and warrant concern for several reasons. First, the health effects can be quite severe. Many hazardous air pollutants are confirmed or suspected carcinogens, or are known or suspected to cause birth defects. Secondly, many hazardous air pollutants can be toxic at very low concentrations; for some chemicals — such as carcinogens — there are no thresholds below which exposure can be considered risk-free.

Industrial facilities are primary sources of toxic air contaminants. Rather than coming out of a smokestack, however, toxic contaminants often result from "fugitive emissions," such as leaking valves and pipes. The electronics industry, including semiconductor manufacturing, has the potential to contaminate both air and water due to the highly toxic chlorinated solvents commonly used in semiconductor production processes. Sources of air toxics go beyond industry, however. Various common urban facilities also produce hazardous pollutants, such as gasoline stations (benzene), hospitals (ethylene oxide), and dry cleaners (perchloroethylene) (see also: Tables A.I, A.II and A.III, below). Automobile exhaust also contains toxic air pollutants such as benzene, ethylene dibromide, and ethylene dichloride. (Lead as a gasoline additive has been phased out in the State of California).

Non-Health Effects Of Air Pollution

Visibility Reduction

Obvious effects of air pollution are visibility reduction and discoloration of the sky — caused by the brownish haze of nitrogen dioxide or by the accumulation of particulate matter in the atmosphere — or both simultaneously. When particles are present in sufficient quantities, distant objects become obscured. Visibility reduction is primarily caused by the following sources:

- Construction and demolition.
- Auto exhaust, diesel soot, and resuspended road dust.
- Wood burning, incineration, and other combustion activities.
- Particles or aerosols formed by photochemical reactions occurring in the atmosphere.
- Agricultural and mining activities.
- Stationary sources such as cement kilns and refineries.
- Naturally occurring particles from salt water, vegetation, soil, and wind erosion processes.
- Atmospheric particles, normally too small to affect visibility, which grow to visibility-reducing size through the process of agglomeration (clustering) or through condensation, where moisture condenses on small particles causing them to grow to visibility-reducing size.

Visibility in the Bay Area can vary dramatically, depending on meteorological conditions. The major factors causing these fluctuations are the amount of moisture in the air, the strength of the air currents, and the volume of air available for dilution and dispersion of visibility-reducing particles. Under adverse weather conditions, particularly high heat and intense sunlight, some or all of the factors discussed above cause visibility to become very restricted. These conditions are especially common in summer and early fall.

During the winter months, visibility-reducing particles from photochemical activity are greatly diminished due to colder temperatures and the decreased intensity of ultraviolet light. Thus, when restricted visibility occurs during this period, it is often caused by smoke and dust particles and the growth of particles through agglomeration and condensation.

Visibility is a most precious commodity in the Bay Area. Studies have shown that the reduction of visibility or appearance of visible pollutants such as PM_{10} or NO_2, substantially reduces property values (Loeman, 1980).

Effects on Materials

Effects on materials vary widely in type and severity among the different contaminants. For example, ozone, the primary constituent of photochemical smog, can harden and crack rubber materials, causing them to lose their flexibility. It also affects other types of synthetic materials; for example, it can weaken nylon, and can cause fabric dye fading and paint damage.

Other pollutants in combination produce synergistic effects, causing greater damage than each could cause alone. The interaction of sulfur dioxide and particulate matter has a greatly enhanced ability to corrode materials such as steel, iron, copper, zinc, tin, and stone. In some industries, extensive measures must be taken to protect equipment from polluted air. In the aerospace industry, for example, where silver and other metals used in sensitive electronic equipment are particularly vulnerable to corrosion, great care must be taken to protect components.

Particles settling on buildings, automobiles, outdoor furniture, and other surfaces are usually considered to be dust, dirt or soot nuisances at minimum, even when they do not produce damage to health or materials.

Plant Damage

The effects of air pollution on plants, crops, and forests depend both on plant susceptibility and the types of pollutants involved. Plant damage is difficult to assess because damage is often manifested as stunted growth or diminished yields, rather than the death of the plant.

Among the recorded effects of air pollution on plants are flower and foliage discoloration; bloom failure; plant malformation; leaf, needle, and fruit drop; and failure of fruit to ripen. Particularly vulnerable to ozone damage are grapes, lettuce, spinach and many garden flowers and shrubs. Additionally, some greenhouse crops, including flowers and some herbs, suffer damage when certain hydrocarbon levels are elevated.

Localized plant damage has been noted in the Bay Area from other gases, including nitric oxide, hydrogen chloride, formaldehyde, sulfur dioxide, and fluorides. Sulfur dioxide, for example, is particularly damaging to pasture crops and leafy vegetables. And although a highly localized problem, fluoride threatens both plants and animals. The susceptibility of plants to fluoride damage varies greatly; apricots, grapes, strawberries, bulb crops, and conifers have low resistance. The more serious effect is seen in animals, who may consume fodder that offers no detectable signs of damage but in fact contains relatively high concentrations of fluorides. Over a period of time, animals build up a concentration of fluorides in their tissues, which eventually leads to fluorosis, a bone disease.

Stationary Sources

The tables below list types of stationary sources of air contaminants in the Bay Area. Table A.I lists sources which produce an array of criteria, toxic and nuisance emissions. Table A.II lists sources with high potential for emitting air toxics; a toxics screening analysis is required at minimum if the facility is to receive a permit from the Air District. Table A.III lists sources with the highest potential for toxic contaminants; such sources require a full health risk assessment in accordance with procedures acceptable to the Air District's Air Toxic Evaluation Section.

Table A.I INDUSTRIAL OPERATIONS WITH HIGH POTENTIAL FOR AIR CONTAMINANTS

Industrial Operation	Air Contaminants (criteria, toxic and nuisance)
Power Plants	sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter
Oil Refineries	SO_2, hydrogen sulfide (H_2S), particulate matter, hydrocarbons, mercaptans, odors
Sewage Treatment Plants	H_2S, chlorine, mercaptans, odors
Cement Batch Plants	cement particles, dust
Feed Lots, Agricultural Operations	odors
Dumps (Landfills) — Class I (Chemical)	various toxic and odorous materials
Dumps (Landfills) — Class II (Garbage)	odors, dust
Rendering Plants	amines, odors
Electronic Manufacturing	solvents (volatile organics — VOCs), toxic gases (arsene, phosphine)
Fiberglass Operations	styrene
Chemical Manufacturing	various toxic and/or odorous compounds

Table A.II SOURCES WITH HIGH POTENTIAL FOR AIR TOXICS

The following types of facilities require screening analyses.

- Chrome platers
- Facilities that operate with combustion of solid fuels
- Dry cleaners — those not using dry-to-dry machines and those using more than 100 gallons per year of solvent
- Users of flares
- Gasoline distribution (except service stations)
- Groundwater strippers
- Incinerators (any kind)
- Landfills and landfill gas treatment/collection
- Organic chemical manufacturing
- Pesticide manufacturing
- Petroleum refineries and processing units
- Sterilizers (any kind)
- Facilities with organic emissions of more than ten pounds per day
- Wastewater treatment, sewerage disposal, etc.

Table A.III SOURCES WITH VERY HIGH POTENTIAL FOR AIR TOXICS

The following types of facilities require health risk assessment.

- Hazardous waste incinerators
- Commercial hazardous waste treatment facilities
- Municipal solid waste treatment and related resource recovery operations
- Power generation facilities using solid fuels

APPENDIX B: AIR QUALITY LAWS, PROGRAMS AND STANDARDS

This appendix contains a discussion of the key federal, state, and local regulations and programs that establish the legal framework for protecting and improving air quality in the Bay Area. As categorized below, some of these regulations have air quality improvement as their primary purpose; others deal with air quality within the context of other public objectives. This appendix concludes with a table of the national and state ambient air quality standards — the quantitative air quality objectives that the Bay Area is required to attain.

Federal Programs

Central To Air Quality Management

Federal Clean Air Act and 1990 Amendments. National ambient air quality standards (NAAQS) were established in 1970 by the federal Clean Air Act for six pollutants: carbon monoxide, ozone, particulates, nitrogen dioxide, sulfur dioxide and lead. These pollutants are commonly referred to as "criteria" pollutants because they are considered the most prevalent air pollutants that are known to be hazardous to human health and because criteria documents, including ambient air quality standards, have been prepared for each of these contaminants.

The Act required states exceeding the NAAQS to prepare air quality plans showing how the standards were to be met by December 1987. The act was amended in 1977, and again in 1990, to extend the deadline for compliance and required that revised State Implementation Plans (SIP) be prepared. Failure to submit and implement an acceptable plan meant the state could be denied federal highway funding and/or be required to increase emission offsets for industrial expansion. The 1990 Amendments established categories of severity for nonattainment areas ("marginal" to "extreme") for nonattainment areas. SIP requirements varied, depending on degree of severity. (For a discussion of the Bay Area's portion of the California SIP, see "Bay Area Regional Agencies and their Programs" below.)

The conformity provisions of the Act are essentially designed to ensure that federal agencies contribute to, instead of jeopardizing, efforts to achieve the national air quality standards. In November of 1993, EPA issued two regulations implementing these provisions. The transportation conformity regulation deals with transportation projects; the general conformity regulation addresses actions of federal agencies other than the Federal Highway Administration and the Federal Transit Administration.

The primary requirements of transportation conformity of note to local governments are that transportation plans and programs cannot produce more

emissions than budgeted in the SIP. Projects receiving federal funds or approvals also must undergo localized air quality modeling. Finally, emissions from local projects with no federal funding must be included in regional plans and programs, if the sponsoring agency receives any form of federal funds.

General conformity applies to a wide range of actions or approvals by federal agencies. Potentially covered by the regulation are such actions of concern to local governments as decisions on wastewater treatment facilities and airport expansions. Essentially, projects are subject to general conformity if they generate more emissions than de minimis thresholds set in the rule (currently 100 tons per year of VOC, NOx, or CO in the Bay Area), and that are not specifically exempted by the regulation. Such projects are required to fully offset or mitigate the emissions caused by the action. This includes both direct emissions and indirect emissions over which the federal agency has some control.

The U.S. EPA also has programs for identifying and regulating toxic air pollutants (air toxics). The Clean Air Act Amendments of 1990 directed EPA to set standards for air toxics and to require companies to sharply reduce emissions of controlled chemicals; it specified 174 industrial sources that are to be regulated. An industry is classified as a major source — and must be regulated — if it emits ten tons per year of any of the listed air toxics, or a combination of 25 tons or more of all listed air toxics.

Relevant to Air Quality Management

National Environmental Policy Act (NEPA). NEPA requires that major projects to be conducted or approved by the federal government be subject to environmental assessments. If the potential for significant adverse environmental impacts exists, an Environmental Impact Statement (EIS) must be prepared and circulated to affected jurisdictions and the interested public.

Intermodal Surface Transportation Efficiency Act, 1991 (ISTEA). This law requires a transportation planning process that includes consideration of 15 factors, two of which address consistency with adopted land use plans and potential environmental effects. ISTEA also provides funds for transportation projects and activities that contribute to meeting air quality standards, including transit, pedestrian, and bicycle-oriented projects. The Congestion Management and Air Quality Improvement Program (CMAQ) directs funds toward transportation projects that will contribute to the attainment of national ambient air quality standards for ozone and carbon monoxide. The funds are distributed based on population size and severity of a region's air pollution problem.

California Programs

Central To Air Quality Management

California Clean Air Act, 1988. The 1988 California Clean Air Act (CCAA) — amended in 1992 — requires attainment of California's ambient air quality standards which in many cases are more stringent than the national standards. In addition to the six criteria pollutants regulated by the federal Clean Air Act, California has established standards for three other pollutants: hydrogen sulfide, sulfates, and vinyl chloride. In general, the CCAA requires regions like the Bay Area — areas which exceed certain state air quality standards for criteria pollutants — to reduce harmful pollutants by five percent or more per year or implement all feasible measures to meet the state air quality standards as expeditiously as possible. Regional air quality districts like the Bay Area Air Quality Management District, must prepare air quality plans specifying how state standards would be met. State agencies are required to implement a number of statewide automobile emission control regulations, including the "Smog Check" program.

State Motor Vehicle Emission Control Program. The California Air Resources Board (ARB) regulates the amount of pollutants that can be emitted by new motor vehicles sold in California. California motor vehicle emission standards are more stringent than the federal standards and have become increasingly more stringent since they were first imposed in 1961 by the State Motor Vehicle Pollution Control Board (the predecessor to the ARB). To help meet the state ambient air quality standards, the ARB has instituted regulations that will require manufacturers selling vehicles in California to manufacture and phase-in a proportion of motor vehicles in the following categories: *Transitional Low Emission Vehicles, Low Emission Vehicles, Ultra-Low Emission Vehicles, and Zero Emission Vehicles* (e.g., electric vehicles — 2% of California-sold vehicles by 1998 and 10% by 2003). These requirements apply to passenger vehicles and are intended to reduce emissions of carbon monoxide, reactive hydrocarbons, and nitrogen oxides. The ARB has also set requirements for the distribution of alternative fuels.

In related programs, the ARB has implemented a heavy duty vehicle inspection program, which applies to diesel-powered trucks and buses. The ARB is also working on fuel requirements that would reduce toxic emissions from motor vehicles. The California Bureau of Automotive Repair continues to administer the vehicle inspection and maintenance program (I/M or Smog Check Program).

Air Toxics "Hot Spots" Information and Assessment Act, 1987. The Air Toxic "Hot Spots" Information and Assessment Act was enacted by the California Legislature to identify toxic air contaminant hot spots where emissions from specific sources may expose individuals to elevated risk of adverse health effects. The state Department of Health Services and the Air Resources Board work together to administer the provisions of this Act statewide; but its implementation and enforcement are the responsibility of local/regional air districts. The Act requires that a business or other

establishment, identified as a significant source of toxic emissions, notify the affected population and provide them with information about health risks posed by the emissions. (While not part of the Hot Spots program, the State of California Health and Safety Code, Section 25534 allows "Administering Agencies" — usually county health departments — to require "Risk Management and Prevention Plans" of facilities which handle hazardous materials.)

Relevant to Air Quality Management

California Planning Law and Guidelines. The State of California does not require air quality elements for general plans. Seven elements are mandated by the California Government Code; air quality is mentioned only as an optional issue in the "Conservation" element. Nonetheless, the Air District has been urging all cities and counties in the Bay Area to include an air quality element or section in their general plans for the past several years.

One of the most important features of California general plans is that even though air quality elements are not mandated, general plans are required by law to be consistent with any air quality policies and programs that exist within local jurisdiction. Local plans must also be consistent with regional air quality plans such as the Bay Area Clean Air Plan (see Appendix G).

California Transportation Plan. The most recent state transportation plan prepared by Caltrans addresses air quality, and cites the funding of transportation control measures (TCMs) as a high priority. In addition, telecommuting is promoted as well as other "nonstructural" transportation solutions such as: reducing demand, increasing transit service, and implementing market-based measures (e.g., a demonstration project of congestion pricing on the San Francisco-Oakland Bay Bridge).

California Environmental Quality Act (CEQA). All cities and counties are required by the California Environmental Quality Act (CEQA) to determine whether land-use plans and development projects have a significant effect on air quality. In general, projects are considered likely to have a significant air quality effect if they: (1) cause a violation of any ambient air quality standard, (2) contribute substantially to an existing or projected air quality violation, or (3) expose members of the population who are especially sensitive to air pollution to substantial air pollutant concentrations. If the Initial Study indicates that a project has the potential to result in such impacts, the project sponsor must prepare an Environmental Impact Report (EIR) that includes a mitigation plan specifying how these significant effects will be reduced or avoided. The lead agency — usually a city or county — must monitor the mitigation plan to ensure that the project's adverse effects are reduced to an insignificant level.

The "Master EIR" concept, advocated in recent proposals to streamline CEQA, would allow the local general plan, along with its EIR, to qualify as the required environmental assessment of projects that are totally consistent with that broader plan. This could greatly

streamline the project approval process in respect to CEQA.

Local Coastal Program, 1980. This program, set up by the statewide California Coastal Commission, requires conformity with state air quality regulations for the coastal programs of each city and county bordering the Pacific Ocean.

Bay Area Regional Agencies and Their Programs

Central To Air Quality Management

Bay Area Air Quality Plan, 1979 and 1982. The Bay Area Air Quality Plan is a regional plan required by the federal government. It is prepared jointly by the Bay Area Air Quality Management District, the Metropolitan Transportation Commission (MTC), and the Association of Bay Area Governments (ABAG) to address how the Bay Area will attain the national air quality standards. The plan contains stationary source controls, motor vehicle emission controls, and transportation system improvement measures that would reduce the amount of air pollutants released into the atmosphere. These measures are implemented primarily by the Air District, ARB and MTC, respectively.

The federal Clean Air Act (1970, 1977) required the Air District, MTC, and ABAG to prepare the first Bay Area Air Quality Plan in 1979 and then amend it in 1982. Its primary objective was to attain national air quality standards by 1987. The 1982 Air Quality Plan required that: (1) major stationary sources install emission control devices, (2) new sources apply for air quality permits, (3) registered Bay Area vehicles pass a vehicle inspection and maintenance program (e.g., "Smog Check") every two years, (4) transportation control measures be implemented, and (5) MTC assess the conformity of regional transportation plans, programs and projects to air quality objectives.

Although these requirements resulted in significant air quality improvement, the Bay Area failed to attain national air quality standards for carbon monoxide and ozone by 1987. In 1989, in response to a court order, MTC implemented a contingency plan to assure that the Bay Area was making all reasonable further progress toward attaining national air quality standards. This plan included additional transportation control measures and a revised conformity assessment procedure.

Ozone Attainment and Maintenance Plans, 1993. Under the 1990 federal Clean Air Act Amendments, the Bay Area is classified as "moderate" for ozone. The federal air quality plan requirements include: (1) new procedures for assessing conformity of plans, programs and projects with air quality objectives; (2) a plan designating how volatile organic compounds will be reduced by 15 percent by 1996; and (3) a plan to achieve the national ozone standard by 1996. The Bay Area Air Quality Management District, the Metropolitan Transportation Commission and the Association of Bay Area Governments prepared and submitted two separate air quality plans in 1993 to address updated federal

requirements for the control of ozone in the Bay Area. The San Francisco Bay Area is in the unusual position of creating two plans — an Attainment Plan and a Maintenance Plan — because the official air quality status of the Bay Area may be changing.

Through 1989, the Bay Area air basin had continued to violate the national ozone standard. As a result, the Bay Area currently carries a formal designation of "non-attainment" for the national ozone standard. But because of significant improvements in Bay Area air quality over the past several years, and indeed over the last couple of decades, the region may have reached the national ozone standard for the first time, based on air monitoring data collected since 1990.

When an air district meets an air pollutant standard, it is designated as "attainment" for that standard. When a standard is not met, the air district is classified as "nonattainment" and is required to prepare a plan which sets forth a strategy for achieving the standard in the future. The *San Francisco Bay Area Nonattainment Area and Rate-of-Progress Plan for the National Ozone Standard* (Attainment Plan) has been prepared to satisfy this requirement.

The Attainment Plan, and recent monitoring data, demonstrates that the Bay Area will achieve the national ozone standard by or before 1996, the deadline for attainment for "moderate" areas. The Attainment Plan also incorporates a "Rate-of-Progress" calculation for volatile organic compounds, precursors to the formation of ozone.

In fact, because the District monitoring records show that the Bay Area attained the national ozone standard in 1992, the *San Francisco Bay Area Redesignation Request and Maintenance Plan for the National Ozone Standard* (Ozone Maintenance Plan) was prepared. This plan shows that the Bay Area currently meets the national ozone standard and outlines how the Bay Area will maintain the standard in the future. The Maintenance Plan includes air monitoring data, a demonstration of continuing attainment for at least ten years, contingency measures in case maintenance of the standard is at risk, as well as certain administrative requirements.

Neither of the two plans described in this section includes any new control strategies or control measures. The Maintenance Plan states that the national ozone standard has already been met and indicates that, with control measures already in place, ozone levels can be expected to continue decreasing. The Attainment Plan shows that, even when applying the required modeling procedures, the standard would be attained by 1996. Both plans do include an improved Inspection and Maintenance Program (Smog Check) as a contingency measure in the event that the current strategies do not maintain the standard.

If the Bay Area is successfully reclassified as "attainment" for ozone, then the Attainment Plan will no longer be necessary. If the Redesignation Request is unsuccessful, or future exceedances cause the Bay Area air basin to violate the national ozone standard prior to formal redesignation, the Attainment Plan will become the

Bay Area's blueprint for achieving the national ozone standard.

Carbon Monoxide Attainment - Contingency Plan, 1993. The Bay Area is currently classified as a "moderate" nonattainment area for the national carbon monoxide standard. As a moderate area, the region is required to prepare and submit a contingency plan. The plan was prepared by the Air District, MTC and ABAG in 1993. It proposes improvements in the motor vehicle inspection and maintenance program — if the CO standard is not attained by the December 31, 1995 deadline.

Carbon Monoxide Maintenance Plan, 1994. From 1992 through 1993, no Air District monitor registered an exceedance of the national carbon monoxide standard. Therefore, a *San Francisco Bay Area Redesignation Request and Maintenance Plan for the National Carbon Monoxide Standard* (Carbon Monoxide Maintenance Plan) was adopted in 1994 by the three regional agencies.

Bay Area Clean Air Plan, 1991. The Bay Area 1991 Clean Air Plan (CAP) is required by the 1988 California Clean Air Act. Prepared by the Air District in cooperation with MTC and ABAG, its main objective is to attain state air quality standards for ozone and carbon monoxide. The CAP includes a comprehensive strategy to reduce emissions from stationary, area, and mobile sources. The plan has a specific measure which urges cities and counties to formulate and adopt local air quality elements, or the equivalent, in their general plans.

Under the California Clean Air Act nonattainment classifications, the Bay Area is classified as a "serious" air basin for ozone and as a "moderate" air basin for CO. (The State classification system for nonattainment areas uses the designations "Moderate," "Serious," "Severe," and "Extreme.") ARB action to redesignate the Bay Area as an attainment area for the state CO standard is expected in November 1994. The CAP must indicate how the Air District will attain the state ozone standard by the earliest practicable date, including: (1) additional control measures for existing stationary sources, (2) a permitting program that will result in no net increase in emissions from new stationary sources, (3) provisions for indirect source controls, and (4) transportation control measures.

The prime objective of transportation control measures is to reduce vehicle trips and vehicle miles traveled within the region. These measures are geared toward the following: (1) employer-based trip reduction, (2) mobility improvements, (3) implementation support, (4) traffic operation management, (5) user incentives, (6) indirect source review measures, and (7) pricing strategies.

The Air District will also strive to reduce emissions by implementing additional and more stringent stationary source control measures. These include measures to control emissions from surface coating and solvent use, fuels/organic liquids storage and distribution, refinery and

chemical processes, combustion of fuels, and other industrial/commercial processes.

The California Clean Air Act of 1988 expanded the scope and accelerated the pace of air pollution control efforts in California. If possible, air quality plans should achieve a reduction in district-wide emissions of 5% per year for each nonattainment pollutant or its precursors (Sec. 40914). As an alternative strategy, (employed in the Bay Area CAP), the adoption of all feasible measures on an expeditious schedule is acceptable, even if a district is unable to achieve 5% annual reduction (Sec. 40914 [b] [2]).

Other legal requirements applicable to the Bay Area — and of interest to cities and counties — include the following:

- Indirect source and area source control programs.
- A regional public education program.
- Transportation controls to achieve a 1.4 average vehicle ridership during weekday commute hours by 1999, substantial reduction in the rate of increase of vehicle trips and miles traveled and no net increase in motor vehicle emissions after 1997 (Sec. 40920 [a] [2]).
- An assessment of cost-effectiveness of proposed control measures (Sec. 40922).
- Transport mitigation requirements (Sec. 39610[b]).

After ARB approval of the Plan, additional or continuing legal requirements which must be carried out by the Air District include:

- An annual progress report on control measure implementation and, every third year, an assessment of the overall effectiveness of the program (Sec. 40924).
- A review of the Plan every three years to correct for deficiencies and to incorporate new data. Thus the Air District is required to revise the CAP in 1994 and 1997 (Sec. 40925).

Toxic Air Contaminant Control Program. The Toxic Air Contaminant Control Program is a regional program administered by the Air District. Its main objective is to reduce public exposure to toxic air contaminants.

Odorous Substances Regulation. The Air District has enacted an odorous substance control program as part of its effort to control the use and emission of odorous substances within the Bay Area. This program places general limitations on odorous substances and provides the District with authority to respond to public complaints about offensive odors. The regulation is intended to help the public identify and control offensive odors that are not otherwise controlled by other federal or state air quality laws.

Relevant to Air Quality Management

Regional Transportation Plan, 1994. The Metropolitan Transportation Commission's Regional Transportation Plan (RTP) guides Bay Area transportation system improvement projects and shows how they will help attain regional air quality objectives. The plan promotes projects that will provide reasonable and predictable mobility within the region, ensure that all people have equitable access to transportation, support a healthy environment and mitigate any adverse impacts, and promote economic vitality within the region. The plan identifies and evaluates the Bay Area Metropolitan Transportation System (MTS), a network of regionally significant streets and highways, transit systems and intermodal transfer facilities, and recommends projects that will improve its performance. Many of these recommendations implement federal and state TCMs.

Congestion Management Program. Each county in the state is required to establish a Congestion Management Agency (CMA) and prepare a Congestion Management Program (CMP). The main goals of the Congestion Management Program (CMP) are to establish a political process through which countywide roadway congestion can be controlled or relieved, and to develop a comprehensive strategy to respond to countywide transportation needs. State law requires that each Congestion Management Agency (CMA) prepare, implement and biennially update the CMP. The CMP consists of the following basic elements: (1) a CMP transportation network that includes state highways and selected arterials, (2) traffic level of service (LOS) standards for segments on the CMP network, (3) transit LOS standards for county's transit systems, (4) a travel demand program to promote travel by alternative transportation modes (non-single-occupancy vehicle), (5) a land use impact analysis program to evaluate land use development impacts on the CMP network, and (6) a multi-year capital improvement program (CIP) to fund transportation projects that support CMP goals. The CMP must be updated biennially to reflect changing transportation needs and conditions within the county. The CMP CIP must be submitted to MTC every two years to be incorporated into the Bay Area Regional Transportation Improvement Program.

If traffic conditions on a roadway segment or intersection fall below the LOS standard, the local jurisdiction is required to develop a Deficiency Plan. In some instances, cities and counties may be monitoring LOS based upon transportation models, attempting to predict conditions in the future. The intent is to develop plans for deficient segments prior to the actual occurrence of a deficiency. The CMP statutes direct the Bay Area Air Quality Management District, as the air district for most of the nine-county Bay Area, to establish and periodically update a list of improvements, programs and actions which can be used by local governments in developing Deficiency Plans. The list should include items that "...(i) measurably improve the level of service of the system ..., and (ii) contribute to significant improvements in air quality, such as improved public transit service and facilities, other rideshare programs and promotions, improved non-motorized transportation facilities, high occupancy vehicle facilities, and transportation control

items." The statutes also state that "if an improvement, program, or action is not on the approved list, it shall not be implemented unless approved by the local air quality management district."

Transportation Fund for Clean Air (AB 434). Assembly Bill 434 (Sher, 1991) established a vehicle registration surcharge to fund specified transportation control measures (TCMs). This bill gave the Air District the authority to impose a $4 surcharge on motor vehicle registrations within the Bay Area to pay for programs that reduce mobile source emissions. These fees will generate approximately $17 million per year. The Air District directly allocates 40 percent of the funds to county program managers who then distribute the funds to agencies sponsoring eligible projects. The Air District allocates the remaining 60 percent regionwide to public agencies sponsoring the most cost-effective projects.

The projects and programs eligible for AB 434 funds are: (1) ridesharing, trip reduction ordinances/programs, (2) clean fuel buses for schools and transit operators; (3) feeder bus/shuttle service to transit stations; (4) local arterial traffic management; (5) rail-bus integration and regional transit information; (6) telecommuting, congestion pricing, alternative-fuel vehicle demonstration projects; and (7) a smoking vehicle program (citizen reports to the Air District about vehicles with visible exhaust).

Bay Area Cities And Counties

The primary role cities and counties can play in the air quality management process is to implement the local planning instruments that are described throughout this Guidebook. Implementation instruments that can support air quality policies are briefly described below. (For more information, see Appendices E, F, and G.)

General Plan. As mentioned earlier, California planning law and guidelines do not mandate an air quality element in city or county general plans. Yet such an element would be a strong policy instrument for air quality protection in the Bay Area. The key benefit of a separate air quality element is that all other general plan elements and implementation instruments would, by state law, have to be in conformity.

Zoning Ordinances. City and county zoning ordinances contain development regulations that affect the location and intensity of emission sources. The Guidebook text and its appendices discuss such concepts as minimum density residential and work zones within walking distance of fixed-rail transit stations and the advantage of mixed uses that allow persons access to work sites and services by walking or other modes of transportation other than the motor vehicle.

Parking Regulations and Strategies. Parking measures, often incorporated into zoning ordinances, can include maximum spaces allowed per land use or building unit. There can be a substantial air quality benefit when a city or county reduces parking availability or sets

maximums in order to reinforce such desirable features as high-density residential or work place uses near transit stations. A number of parking-related measures are part of the Transportation Control Measure (TCM) aspects of the Bay Area '91 Clean Air Plan and are discussed in Appendix E.

Subdivision Ordinances. Subdivision ordinances indirectly affect the air quality impact of mobile source emissions by specifying how new subdivisions will be improved with roadways, transit facilities, bikeways, and public easements. Specifications may include roadway layout and construction design for subdivisions. Provisions that limit the length of dead-end streets and cul-de-sacs and, in urban areas, require sidewalks connecting residential, service, and work-place areas would benefit air quality. Requirements may include dedication of transit facilities when a subdivision will include more than a specified number of acres or a specified number of dwelling units. Subdivision ordinances could also require the dedication of bikeways where appropriate.

Grading Ordinances. City or county grading ordinances regulate land excavation, grading, filling and clearing activities related to construction. The ordinance should set performance standards or require specific methods, equipment, and materials to minimize and control dust arising from these activities.

Oil and Gas Regulations. Where there are oil and gas exploration ordinances, such as in San Mateo County, they regulate the location and operation of onshore oil or gas wells. The regulation requires that there be plans for all oil and gas exploration and/or production. The plans must demonstrate how any associated adverse air quality impacts will be mitigated.

Table B.I AMBIENT AIR QUALITY STANDARDS

Pollutant	Averaging Time	California Standards [1] Concentration	National Standards[2] Concentration [3]
Ozone	1 Hour	0.09 ppm	0.12 ppm
Carbon Monoxide	8 Hour	9.0 ppm	9 ppm
	1 Hour	20 ppm	35 ppm
Nitrogen Dioxide	Annual Average		0.053 ppm
	1 Hour	0.25 ppm	
Sulfur Dioxide	Annual Average		80 $\mu g/m^3$
	24 Hour	0.04 ppm	365 $\mu g/m^3$
	1 Hour	0.25 ppm	
Suspended Particulate Matter (PM_{10})	Annual Arithmetic Mean		50 $\mu g/m^3$
	Annual Geometric Mean	30 $\mu g/m^3$	
	24 Hour	50 $\mu g/m^3$	150 $\mu g/m^3$
Sulfates	24 Hour	25 $\mu g/m^3$	
Lead	Calendar Quarter		1.5 $\mu g/m^3$
	30 Day Average	1.5 $\mu g/m^3$	
Hydrogen Sulfide	1 Hour	0.03 ppm	
Vinyl Chloride (chloroethene)	24 Hour	0.010 ppm	
Visibility Reducing Particles [4]	8 Hour (10 am to 6 pm PST)	10-mile visual range when relative humidity is less than 70%	

ppm = parts per million. $\mu g/m^3$ = micrograms per cubic meter.

FOOTNOTES

1. California standards for ozone, carbon monoxide (except Lake Tahoe), sulfur dioxide (1-hour and 24-hour), nitrogen dioxide, suspended particulate matter - PM_{10}, and visibility reducing particles are values that are not to be exceeded. The standards for sulfates, lead, hydrogen sulfide, and vinyl chloride are not to be equaled or exceeded. If the standard is for a 1-hour, 8-hour or 24-hour average (i.e., all standards except for lead and the PM_{10} annual standard), then some measurements may be excluded. In particular, measurements are excluded that ARB determines would occur less than once per year on the average.

2. National standards other than for ozone and those based on annual averages or annual arithmetic means are not to be exceeded more than once a year. The ozone standard is attained if, during the most recent three-year period, the average number of days per year with maximum hourly concentrations above the standard is equal to or less than one.

3. National air quality standards are set at levels determined, by the U.S. Environmental Protection Agency, to be protective of public health with an adequate margin of safety. As the table indicates, the State of California has set more stringent standards for a number of contaminants, based on independent medical judgement.

4. This standard is intended to limit the frequency and severity of visibility impairment due to regional haze and is equivalent to a 10-mile nominal visual range when relative humidity is less than 70 percent.

APPENDIX C: AIR POLLUTION – STATUS, PROBLEMS AND TRENDS

Status Relative to National and State Ambient Air Quality Standards

In terms of air quality, the San Francisco Bay Area could be considered the cleanest major metropolitan area in the United States. In fact, although the Bay Area has not yet been officially redesignated by the U.S. Environmental Protection Agency as having attained the national ozone standard, the Air District believes the region has actually achieved the criteria for such recognition and has applied to EPA for redesignation.

The region has also made progress in reducing carbon monoxide levels in the Bay Area. The Air District's air monitoring records of 1992 and 1993 demonstrate attainment of the national and state eight-hour standard (9 parts per million, or ppm, in both cases) (Table C.II.a) and neither the national one-hour standard (35 ppm) nor the state one-hour standard (20 ppm) have been exceeded since the 1980s.

The Bay Area does continue to violate a number of air quality standards, however. For instance, the state ozone standard is violated roughly 20 days each year. The state one-hour ozone standard — 9 parts per hundred million (9 pphm) — is considerably more stringent than the national standard of 12 pphm. Table C.II.c indicates the number of days the state ozone standard has been exceeded in recent years..

With regard to fine (respirable, inhalable) particulate matter (PM_{10}), the state and national standards have both been exceeded in recent years. Since 1990, the state 24 hour PM_{10} standard has been exceeded on up to 30% of monitoring days. The national standard was exceeded a few times in 1990 and 1991, but has not been exceeded since then (Table C.II.d).

Additional criteria pollutants include nitrogen dioxide, sulfur dioxide, sulfates, lead, hydrogen sulfide, and vinyl chloride (chloroethane). Neither state nor national ambient air quality standards of these chemicals have been violated in recent decades. Table C.I summarizes the Bay Area's attainment status for the state and national standards.

Problems and Trends

Throughout the Bay Area, automobile ownership and use is increasing at a faster rate than population growth. Countering this trend is the move toward cleaner vehicles with fleet turnover and the introduction of cleaner fuels. Overall, trend projections indicate a net reduction in the emissions of ozone precursors and carbon monoxide but fine particulate emissions are expected to increase.

Table C.III shows projected future emissions of criteria pollutants for the Bay Area for the years 1995, 2000, and 2010 in terms of total emissions and motor vehicle

emissions. Total emissions and the amount and proportion attributable to motor vehicles decline sharply, especially for reactive hydrocarbons and carbon monoxide. A smaller decline in motor vehicle emissions of nitrogen oxides (NO_x) is predicted, and a small increase is predicted for SO_2 emissions. Most significant is the predicted increase in PM_{10} emissions.

Regionally, the most complex air quality problem has been ozone. Ozone is formed in the atmosphere through a complex series of photochemical reactions involving reactive organic gases (ROG) and (NO_x). Motor vehicles account for the majority of the ROG and NO_x emissions. Although the Bay Area's highest ozone levels can fluctuate from year to year, standards are exceeded most often in the Santa Clara, Livermore, and Diablo valleys.

In contrast to ozone, carbon monoxide (CO) is more a subregional problem in the Bay Area, because CO is a nonreactive pollutant with one major source — motor vehicles. Based on the Air District's emission inventories, about 65 to 85 percent of CO in the Bay Area is generated by motor vehicles. The areas with the highest CO levels typically have been those with high levels of vehicular traffic. CO levels are strongly influenced by meteorological factors such as wind speed and atmospheric stability. As a result, the eight-hour CO standards have been occasionally exceeded in those parts of the Bay Area subject to a combination of high traffic density and susceptibility to the occurrence of surface-based radiation inversions, during the winter months. The CO standards have been exceeded most recently in San Francisco, San Jose and Vallejo prior to 1992.

Particulate levels in the Bay Area are typically low near the coast, and higher inland, with the highest levels in dry, sheltered valleys, such as the Santa Clara, Livermore, and Diablo valleys. The major human-generated (anthropogenic) sources in the Bay Area include motor vehicle travel over paved and unpaved roads, demolition and construction activity and woodburing in fireplaces and stoves. Agricultural operations and burning also contribute significantly to particulate concentrations in rural areas. As discussed in the Guidebook and as illustrated in Figure C.2.d, PM_{10} is expected to increase in the coming years.

The major sources of nitrogen oxides (NO_x) are vehicular, residential, and industrial fuel combustion. Concentrations of nitrogen dioxide (NO_2), the most abundant form of ambient NO_x, are highest in the South Bay, where the standard was last exceeded in 1980.

Major sources of ambient sulfur dioxide (SO_2) include activities such as electricity generation, petroleum refining, and shipping. The highest levels of SO_2 are recorded by monitoring stations located in a relatively narrow crescent in northern Contra Costa County, where most of the major sources of SO_2 are located. The SO_2 standard is currently being met throughout the Bay Area, with Bay Area seasonal maximums rarely exceeding 50 percent of the standard, and SO_2 levels at most Bay Area monitoring stations being less than 10 percent of the standard.

Data Sources for Criteria Pollutant Trends

Monitoring Data

The Air District operates a regional air quality monitoring network (Figure C.1) that regularly measures the concentrations of the five major criteria air pollutants discussed above . CO, ozone, and PM_{10} trends for the last decade in the Bay Area are presented in Tables C.II.a, C.II.b, C.II.c and C.II.d. Air District meteorologists have developed isopleth maps (Figures C.4.a, C.4.b and C.4.c) from recent data recorded at these monitoring stations and those of other agencies. These isopleth maps indicate worst-case background levels for the years indicated on each map. City and county planners can use these maps in analyzing air quality impacts of plans and projects (see also BAAQMD, 1985).

Emissions Inventory

The Air District estimates emissions of criteria pollutants from approximately nine hundred source categories. The estimates are based on Air District permit information for "point sources" (e.g. manufacturing industries, refineries, dry-cleaning plants) plus more generalized estimates for "area sources" (e.g. house heating, use of consumer products) and "mobile sources" (trains, ships and planes as well as on-road and off-road motor vehicles). Figure C.2 indicates past estimates and future projections of emissions for the region as a whole; the proportionate role of mobile sources is highlighted in these charts.

In order to be of more use to city and county planners, emissions inventories in Figure C.3 and Table C.IV.a, C.IV.b, and C.IV.c are presented by county. The bar charts of Figure C.3 graphically present the distribution of 1993 emissions among seven land use categories — aggregated from the more than 900 categories of emission sources in the Air District's emission inventory system. Tables C.IV.a, C.IV.b and C.IV.c indicate projections of emissions, by land use category, for 1995, 2000 and 2010. Major individual point sources are listed, by county, in the *Air District Handbook*, Appendix III (BAAQMD, 1993). This list is updated approximately every two years.

The emission inventories and projections assume that the Bay Area will continue to grow as forecasted and that all currently adopted control measures will continue. Among these assumptions are:

- population, housing, employment, economic growth and land use will increase as regionally forecasted (ABAG, *Projections '94*, Dec. 1993).
- cars will become cleaner, as required by California regulations.
- the recently improved "Smog Check" program will continue.
- controls on industry and business will continue.
- currently implemented transportation control measures will continue.

City and county planners should be aware that actions which alter these assumptions may also affect progress toward attainment and maintenance of the ambient air quality standards

Transport of Pollutants

The California Clean Air Act (CCAA), Section 39610 (a), directs the ARB to "identify each district in which transported air pollutants from upwind areas outside the district cause or contribute to a violation of the ozone standard and to identify the district of origin of transported pollutants." The information regarding the transport of air pollutants from one basin to another was to be quantified to assist interrelated basins in the preparation of plans for the attainment of state ambient air quality standards.

Numerous studies conducted by the ARB have identified air basins that are impacted by pollutants transported from other air basins (as of 1993). Among the air basins affected by air pollution transport from the Bay Area are the North Central Coast Air Basin, the Mountain Counties Air Basin, the San Joaquin Valley Air Basin, and the broader Sacramento Area. The Bay Area was also identified as an area impacted by the transport of air pollutants from the Sacramento area.

Other possible transport corridors being studied by the Air District and the ARB are from the Bay Area to the Upper Sacramento Valley and from the San Joaquin Valley Air Basin to the Bay Area.

Toxic Air Contaminants

The Air District has established a number of monitors to track ambient levels of 11 toxic air pollutants: benzene, 1,1,1-trichloroethane (TCA), trichloroethylene (TCE), chloroform (TCM), 1,2-dichloroethane (EDC), 1,2-dibromoethane (EDB), methylene dichloride (DCM), carbon tetrachloride, tetrachloroethylene (perc), vinyl chloride, and toluene. The Air District is also in the process of establishing a monitoring network to trace 1,4-butadiene. Of the toxics monitored by the Air District, state ambient air quality standards have been set for vinyl chloride.

Because the Air District's air toxics monitoring program is relatively new, no trend information is available. Based on ARB information, it is expected that benzene and 1,4-butadiene — both generated largely by motor vehicles — will be reduced substantially when reformulated fuels are introduced. These two toxic compounds together account for more than half the health risk from identified air toxics.

Appendix A discusses toxic air contaminant sources and effects. Appendix B outlines federal, state, and Air District programs for identifying and regulating air toxics.

Global Warming and Stratospheric Ozone Depletion

Global warming and stratospheric ozone depletion are issues which have gained increased public attention over the last decade. Unlike emissions of criteria and toxic air

pollutants, which have local or regional impacts, air emissions contributing to global warming and ozone depletion have a broader, global impact. Yet, as discussed briefly below, local and regional actions can contribute to solutions.

Global warming is a process whereby "greenhouse gases" contribute to an increase in the temperature of the earth's atmosphere. Greenhouse gases are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapor. Like most criteria and toxic pollutants, many of the greenhouse gases are generated by motor vehicles and can be reduced to some degree by sensitive land-use and transportation planning on the city, county and subregional level. These gases allow visible and ultraviolet light from the sun to pass through the atmosphere, but they prevent heat from escaping back out into space. The glass in a greenhouse works in much the same way, keeping the inside of the greenhouse warm in comparison to the outside. Among the potential implications of global warming are rising sea levels and adverse impacts to agriculture, forestry, and natural habitats. In addition, global warming may increase electricity demand for cooling, decrease the availability of hydroelectric power, and affect regional air quality and human health.

One group of greenhouse gases, chlorinated fluorocarbons (CFCs) also depletes stratospheric ozone in addition to causing global warming. Stratospheric ozone, unlike ground-level ozone, is beneficial; it acts as a solar radiation screen reducing the amount of shortwave ultraviolet radiation which can cause skin cancer, damage agricultural crops and increase photochemical smog. By depleting ozone in the upper atmosphere, CFCs not only allow more shortwave ultraviolet radiation to enter the earth's atmosphere, but they are several thousand times more effective than CO_2 in trapping infrared radiation. Since the mid-1930s, CFCs have been used as refrigerants, solvents, and in the production of foam materials. Moreover, CFCs survive in the atmosphere for decades.

National and international agreements have been made to control CFCs and to study air quality problems related to ozone depletion. Although local governments alone cannot solve these global problems, some cities in the Bay Area have already demonstrated that local and regional efforts can make a contribution; e.g., banning the sale and commercial use of plastics made with CFCs.

Table C.I AIR QUALITY STATUS - CRITERIA POLLUTANTS

Pollutant	National Standards	National Classification	State Standards	State Classification
Ozone	No violations since 1989	Moderate Nonattainment Area, Redesignation Request submitted to EPA in 1993	Violations in inland valleys on hot days - 15-25/year	Serious Nonattainment Area
CO	No violations since 1991	Moderate Nonattainment Area, Redesignation Request submittal to EPA expected November 1994	No violations since 1991	Nonattainment - transitional for San Jose Urban Area; reclassification to attainment in November 1994
PM_{10}	Exceedances in Livermore, San Francisco, and San Jose in 1990/991 No exceedances 1992 to mid 1994	Unclassified	Violations throughout region	Nonattainment Area
NO_2, SO_2, Lead and other criteria pollutants	No violations	Attainment Area	No violations	Attainment Area

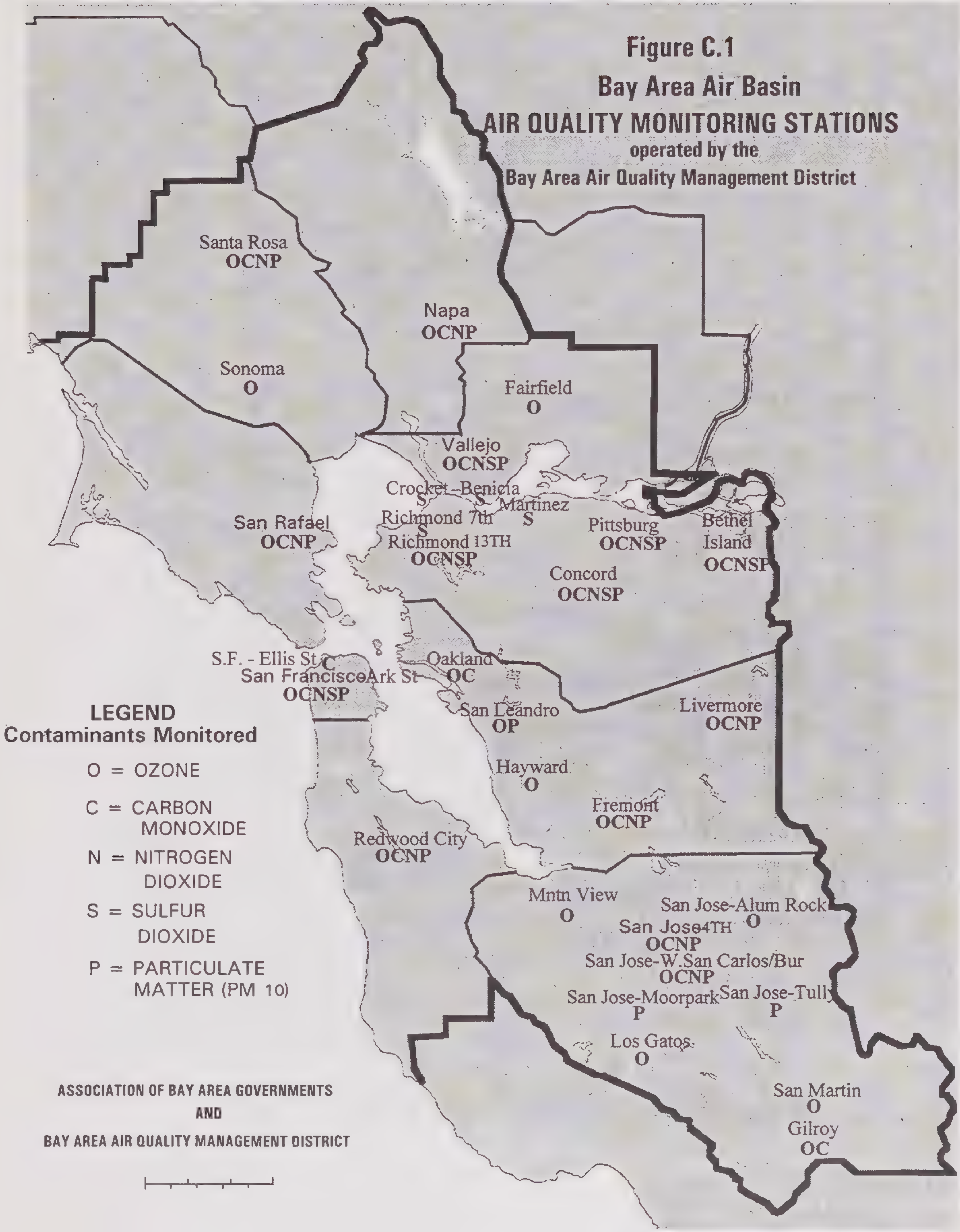


Figure C.1
Bay Area Air Basin
AIR QUALITY MONITORING STATIONS
operated by the
Bay Area Air Quality Management District
Santa Rosa
OCNP
Napa
OCNP
Sonoma
O
Fairfield
O
Vallejo
OCNSP
Crocket
S
Benicia
S
Martinez
S
Richmond 7th
S
Richmond 13TH
OCNSP
San Rafael
OCNP
Pittsburg
OCNSP
Bethel Island
OCNSP
Concord
OCNSP
S.F. - Ellis St
C
San Francisco
Ark St
OCNSP
Oakland
OC
San Leandro
OP
Livermore
OCNP
Hayward
O
Fremont
OCNP
Redwood City
OCNP
Mntn View
O
San Jose-Alum Rock
O
San Jose 4TH
OCNP
San Jose-W.San Carlos/Bur
OCNP
San Jose-Moorpark
P
San Jose-Tully
P
Los Gatos
O
San Martin
O
Gilroy
OC
LEGEND
Contaminants Monitored
O = OZONE
C = CARBON MONOXIDE
N = NITROGEN DIOXIDE
S = SULFUR DIOXIDE
P = PARTICULATE MATTER (PM 10)
ASSOCIATION OF BAY AREA GOVERNMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Table C.II.a EXCEEDANCES OF NATIONAL (AND STATE*) CARBON MONOXIDE (CO) STANDARD

Number Of Days With Maximum 8-Hour Concentration Exceeding 9 Parts Per Million (ppm) — 1983-1993

County	Site	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alameda County	Fremont	0	0	0	0	0	0	0	0	0	0	0
	Livermore	0	0	0	0	0	0	0	0	0	0	0
	Oakland	0	0	0	0	0	0	0	0	0	0	0
Contra Costa County	Concord	0	0	0	0	0	0	0	0	0	0	0
	Pittsburg	0	0	0	0	0	0	0	0	0	0	0
	Richmond	0	0	0	0	0	0	0	0	0	0	0
	Bethel Island	0	0	0	0	0	0	0	0	0	0	0
Marin County	San Rafael	0	0	0	0	0	0	0	0	0	0	0
Napa County	Napa	0	0	0	0	0	0	0	0	0	0	0
San Francisco	Arkansas St/Potrero	0	0	0	0	0	0	0	0	0	0	0
	Ellis Street	0	1	2 (3)	2	1	1	0	0	0	0	0
San Mateo County	Redwood City	1	0	0	0	0	0	0	0	0	0	0
Santa Clara County	Gilroy	0	0	0	0	0	0	0	0	0	0	0
	San Jose-4th Street	2 (3)	5	16	4	0	2 (3)	6	2 (5)	4	0	0
	San Carlos St./Burbank								0	0	0	0
Solano County	Vallejo	1	3 (4)	0	4	0	1	2	0	0 (1)	0	0
Sonoma County	Santa Rosa	0	0	0	0	0	0	0	0	0	0	0
AIR DISTRICT DAYS		4 (5)	8 (9)	16(17)	7	1	3 (4)	8	2 (5)	4 (5)	0	0

*The recorded number of exceedances of the State — as differentiated from the National — Carbon Monoxide 8-Hour Ambient Air Quality Standard is sometimes slightly higher due to prescribed procedures for calculating each. The State Standard is given as 9.0 ppm and is considered to be exceeded when a monitor records a CO 8-hour average level of 9.1 or higher. The National Standard is given as 9 ppm and is considered to be exceeded at a level of 9.5 ppm or higher. In the table above, when the number of days of exceedance in a year differed among the two, the number of days exceeding the State Standard is given in parentheses.

"AIR DISTRICT DAYS" are the number of days in a year that one or more monitoring stations recorded an exceedance of the ambient air quality standard for CO. Air District Days are not usually the sums of the numbers above them in the column because two or more monitoring stations often record exceedances during the same day. More than one exceedance per year, at any one monitoring station, rates a classification of "nonattainment" for CO.

Table C.II.b EXCEEDANCES OF THE NATIONAL OZONE (O_3) STANDARD

Number Of Days With Maximum One-Hour Concentration Exceeding 12 Parts Per Hundred Million (pphm) — 1983 - 1993

County	Site	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alameda County	Fremont	7	5	4	2	4	1	0	1	0	0	1
	Hayward	3	3	1	0	1	0	0	0	0	1	0
	Livermore	8	7	4	3	3	4	2	1	1	0	1
	Oakland	0	0	0	0	0	0	0	0	0	0	0
	San Leandro	3	3	0	0	0	0	0	0	0	0	0
Contra Costa County	Concord	4	3	1	0	3	1	0	0	0	0	2
	Pittsburg	2	1	1	0	2	0	0	0	0	0	1
	Richmond	0	0	0	0	0	0	0	0	0	0	0
	Bethel Island	2	1	2	0	0	0	0	0	0	0	0
Marin County	San Rafael	0	0	0	0	0	0	0	0	0	0	0
Napa County	Napa	0	0	0	0	0	0	0	0	0	0	0
San Francisco	San Francisco	1	0	0	0	0	0	0	0	0	0	0
San Mateo County	Redwood City	2	0	1	0	0	0	0	0	0	0	0
Santa Clara County	Mountain View	5	0	0	1	4	0	0	0	0	0	0
	Gilroy	5	3	2	0	4	1	2	0	1	0	0
	Los Gatos	12	13	4	0	4	1	0	0	0	1	1
	San Jose-4th Street	9	7	2	1	1	0	1	0	0	0	0
	San Carlos St./Burbank								1	0	0	1
	Alum Rock	5	4	2	1	6	0	0	0	0	1	0
Solano County	Fairfield	0	1	0	0	0	1	0	0	0	0	1
	Vallejo		3	0	0	0	0	0	0	0	0	0
Sonoma County	Santa Rosa	0	0	0	0	0	0	0	0	0	0	0
	Sonoma	0	0	0	0	0	0	0	0	0	0	0
AIR DISTRICT DAYS		21	22	8	5	14	5	4	2	2	2	3

"*AIR DISTRICT DAYS*" are the number of days in a year that one or more monitoring stations recorded an exceedance. Air District Days are not usually the sums of the numbers above them in the column because two or more monitoring stations often record exceedances during the same day. More than three exceedances in three years, at any one monitoring station, rates a classification of "nonattainment" for ozone for the entire air basin.

Table C.II.c EXCEEDANCES OF THE STATE OZONE (O_3) STANDARD

Number Of Days With Maximum One-Hour Concentration Exceeding 9 Parts Per Hundred Million (pphm) — 1983-1993

County	Site	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alameda County	Fremont	21	19	8	3	17	7	11	3	6	5	5
	Hayward	7	11	5	1	12	9	1	0	2	1	0
	Livermore	20	32	21	20	10	21	9	8	17	14	7
	Oakland	3	2	0	0	1	1	0	0	0	0	1
	San Leandro	14	11	0	0	0	0	0	0	2	2	3
Contra Costa County	Concord	16	15	10	5	20	10	6	3	4	3	7
	Pittsburg	11	9	3	1	14	8	5	4	0	3	4
	Richmond	2	0	0	0	0	2	1	0	0	0	2
	Bethel Island			8	8	14	7	11	5	3	7	3
Marin County	San Rafael	2	5	0	0	1	1	0	0	0	0	0
Napa County	Napa	3	8	3	0	6	1	2	0	3	0	2
San Francisco	San Francisco	1	1	0	0	0	0	0	0	0	0	0
San Mateo County	Redwood City	8	9	5	1	2	2	1	0	0	0	1
Santa Clara County	Mountain View	16	9	2	1	16	13	6	1	3	1	2
	Gilroy	23	20	18	5	19	23	10	5	5	12	6
	Los Gatos	23	30	20	21	25	12	1	5	7	3	8
	San Jose-4th Street	22	24	12	12	23	12	10	4	6	3	3
	San Carlos St./Burbank								5	0	1	4
	Alum Rock	25	19	16	5	22	13	9	1		5	5
Solano County	Fairfield	3	9	4	0	9	3	4	1	3	3	3
	Vallejo	5	9	5	0	6	5	2	2	2	1	3
Sonoma County	Santa Rosa	1	0	0	0	1	0	0	0	0	0	0
	Sonoma	1	3	3	1	2	2	3	0	3	0	0
AIR DISTRICT DAYS		53	55	45	39	45	41	22	14	23	23	19

"AIR DISTRICT DAYS" are the number of days in a year that one or more monitoring stations recorded an exceedance. Air District Days are not usually the sums of the numbers above them in the column because two or more monitoring stations often record exceedances during the same day.

TABLE C.II.d EXCEEDANCES OF THE STATE (AND NATIONAL*) PARTICULATE MATTER (PM_{10}) STANDARD

Number Of Days With Maximum 24-Hour Concentration Exceeding 50 micrograms per cubic meter ($\mu g/m^3$)1985 - 1993

County	Site	1985	1986	1987	1988	1989	1990	1991	1992	1993
Alameda County	Fremont					5	10	14	4	3
	Livermore		5	5	7	13	10	12 (1)	5	3
	San Leandro							10	2	1
Contra Costa County	Concord		4	6	10	9	6	13	8	2
	Richmond					5	5	9	3	3
	Bethel Island	2	3	5	14	7	7	10	4	6
Marin County	San Rafael		4	5	2	8	4	10	5	1
Napa County	Napa		5	8	8	9	8	11	5	3
San Francisco	San Francisco		5	4	7	13	12 (1)	15	9	5
San Mateo County	Redwood City		9	6	5	10	8	12	7	5
Santa Clara County	San Jose-4th Street	24 (2)	23	22	14	15	9 (1)	10	13	10
	Moorpark				8	13	11	13	8	3
	San Carlos St./Burbank					7	9	14	9	5
	Tully Road						11 (1)	11	11	7
Solano County										
Sonoma County										
AIR DISTRICT DAYS		24 (2)	26	26	24	21	15 (3)	18 (1)	18	10

*In those few instances when the National PM_{10} 24-Hour Standard (150 $\mu g/m^3$) has been exceeded, the number of days of exceedance of the National Standard is given in parentheses.

"AIR DISTRICT DAYS" are the number of days in a year that one or more monitoring stations recorded an exceedance. Air District Days are not usually the sums of the numbers above them in the column because two or more monitoring stations often record exceedances during the same day. Note: the standard monitoring schedule for PM_{10} is every sixth day.

Figure C.2

Bay Area Emission Inventory Projections 1980 - 2010
Annual Average Daily Emissions

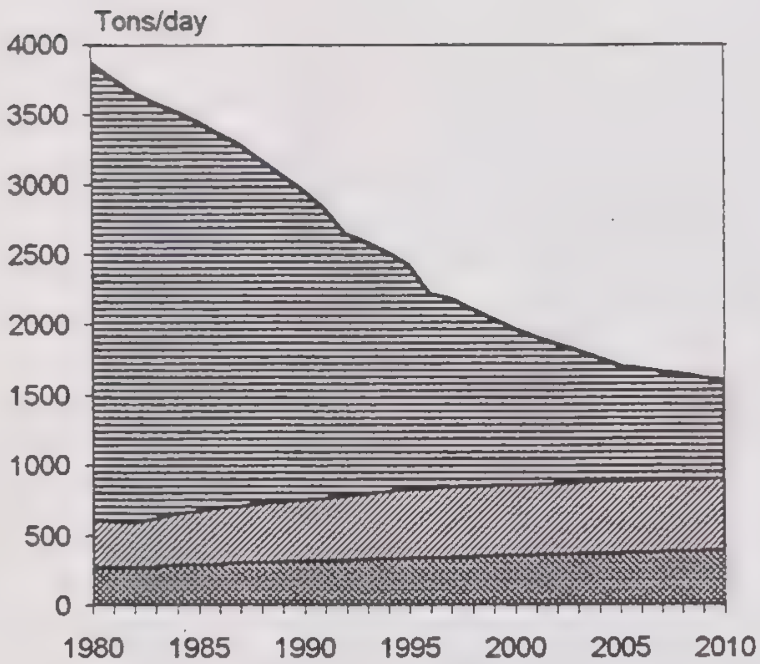


Fig. C-2-a Carbon Monoxide

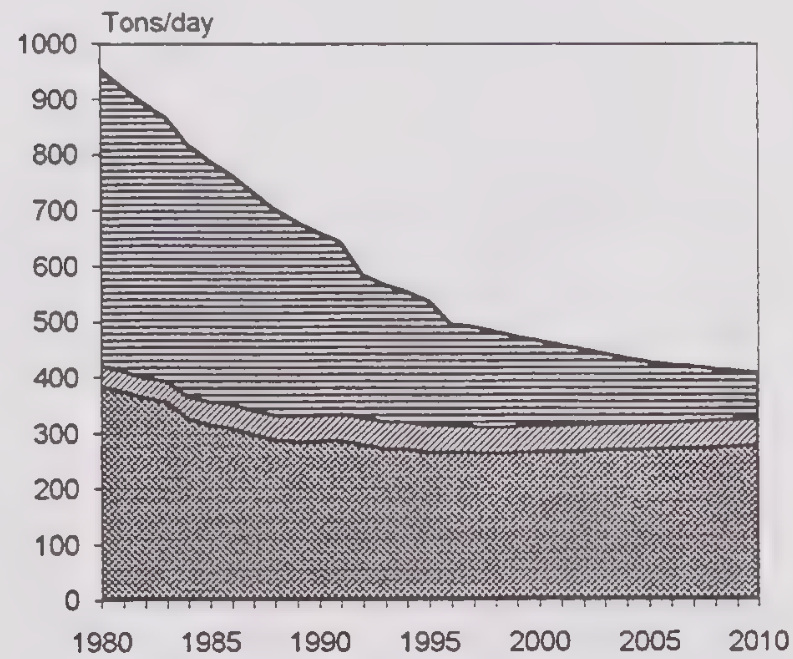


Fig. C-2-b Reactive Organics

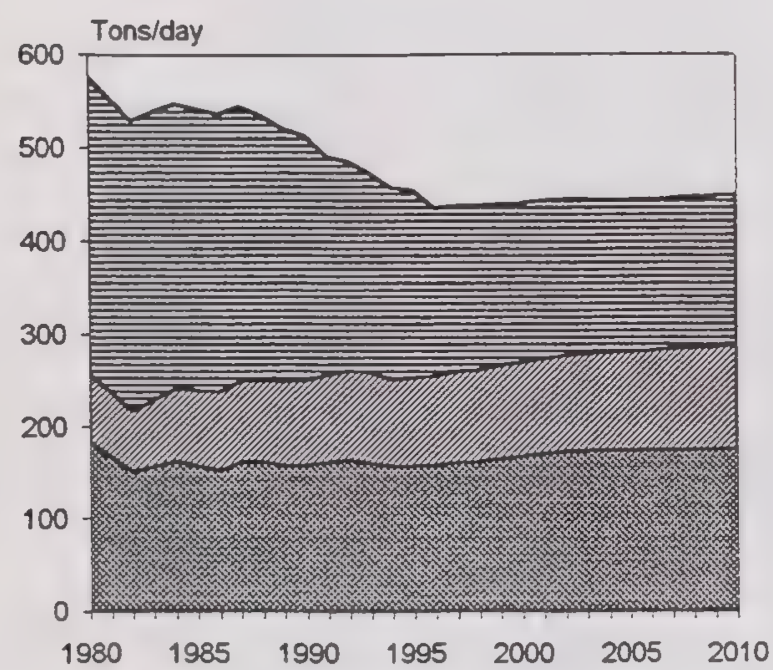


Fig. C-2-c Nitrogen Oxides

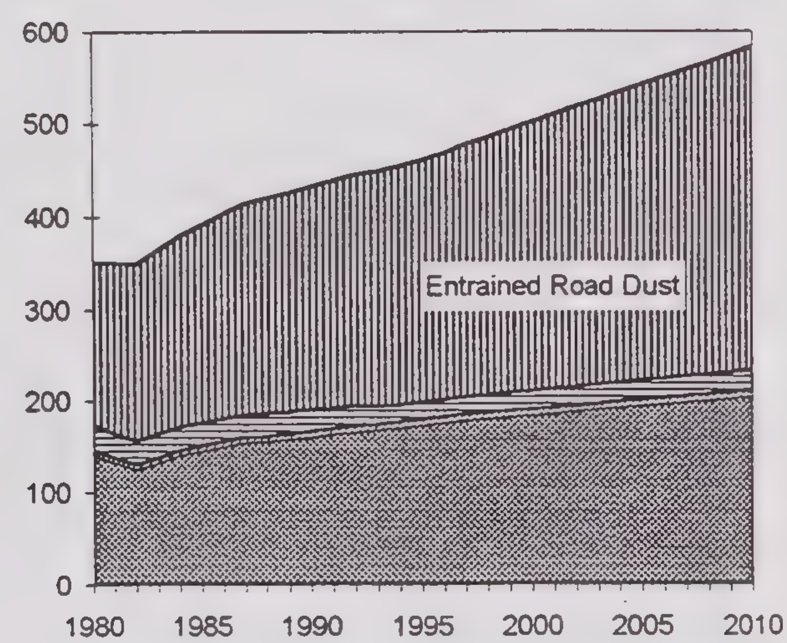


Fig. C-2-d PM-10

Legend

- On-Road Mobile Sources
- Off-Road Mobile Sources
- Other Sources
- Entrained Road Dust

TABLE C.III MOTOR VEHICLE SHARE OF CRITERIA CONTAMINANT EMISSIONS

Total Emissions and Motor Vehicle Emissions Generated in the Bay Area Air Basin

Tons/Day (Annual Average)

Year	CO	HC*	NOx	SO_2	PM-10**
1995					
Total Emissions	2425	535	454	102	462
Motor Vehicle (MV) Emissions	1598	242	200	10	321
(MV as % of Total)	(66%)	(45%)	(44%)	(10%)	(70%)
2000					
Total Emissions	1963	464	441	107	501
Motor Vehicle Emissions	1108	166	171	10	355
(MV as % of Total)	(56%)	(36%)	(39%)	(9%)	(71%)
2010					
Total Emissions	1600	406	449	115	582
Motor Vehicle Emissions	697	88	161	12	427
(MV as % of Total)	(44%)	(22%)	(36%)	(10%)	(73%)

* Reactive organics (anthropogenic — i.e. excluding emissions from natural vegetation)
** Including entrained road dust.
(Projections are based on the Base Year 1990 Air District Emission Inventory.)

Figure C-3 BAY AREA EMISSION INVENTORY (1993 Annual Average) --by COUNTY

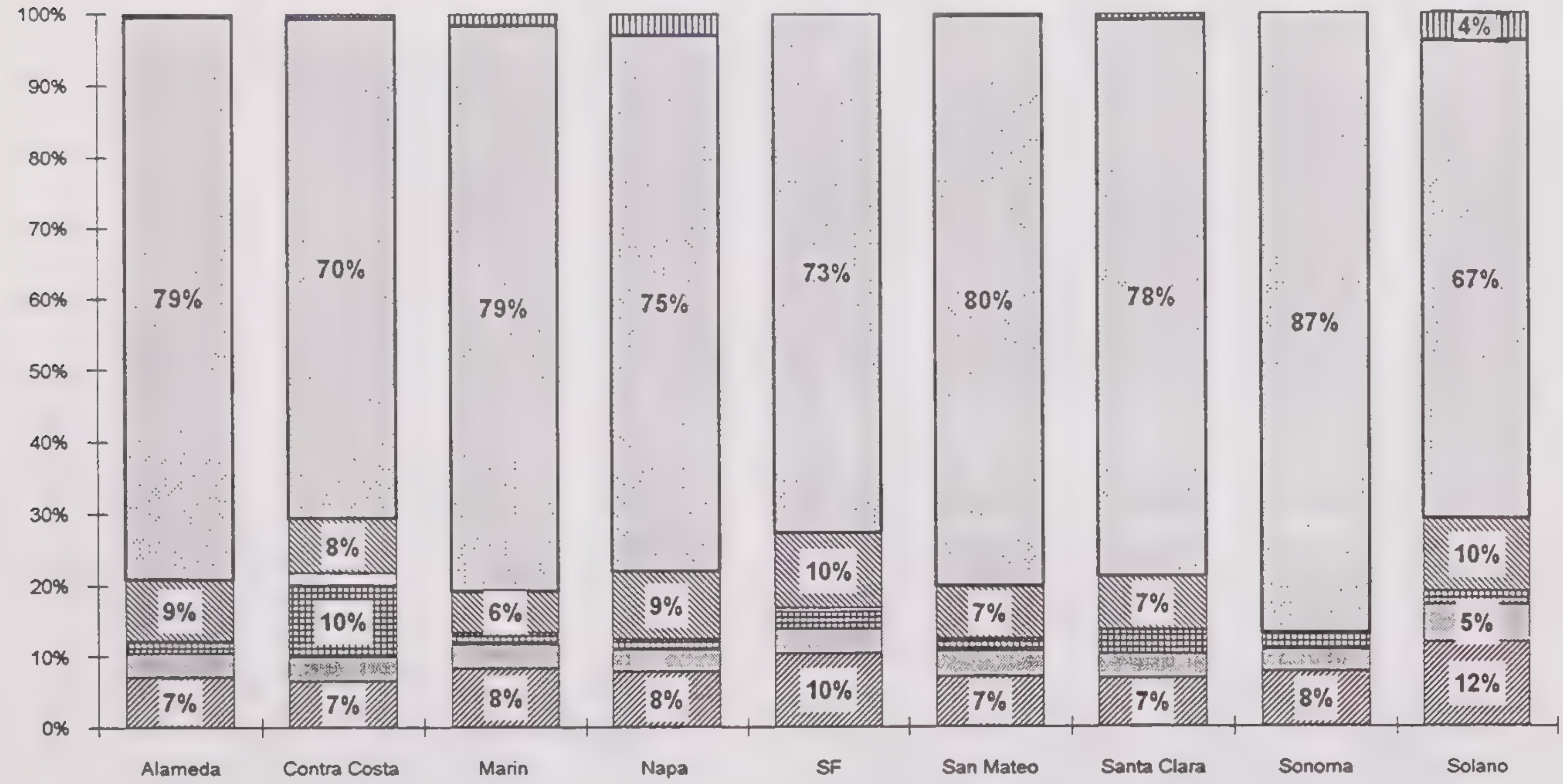


Fig. C-3-a Carbon Monoxide

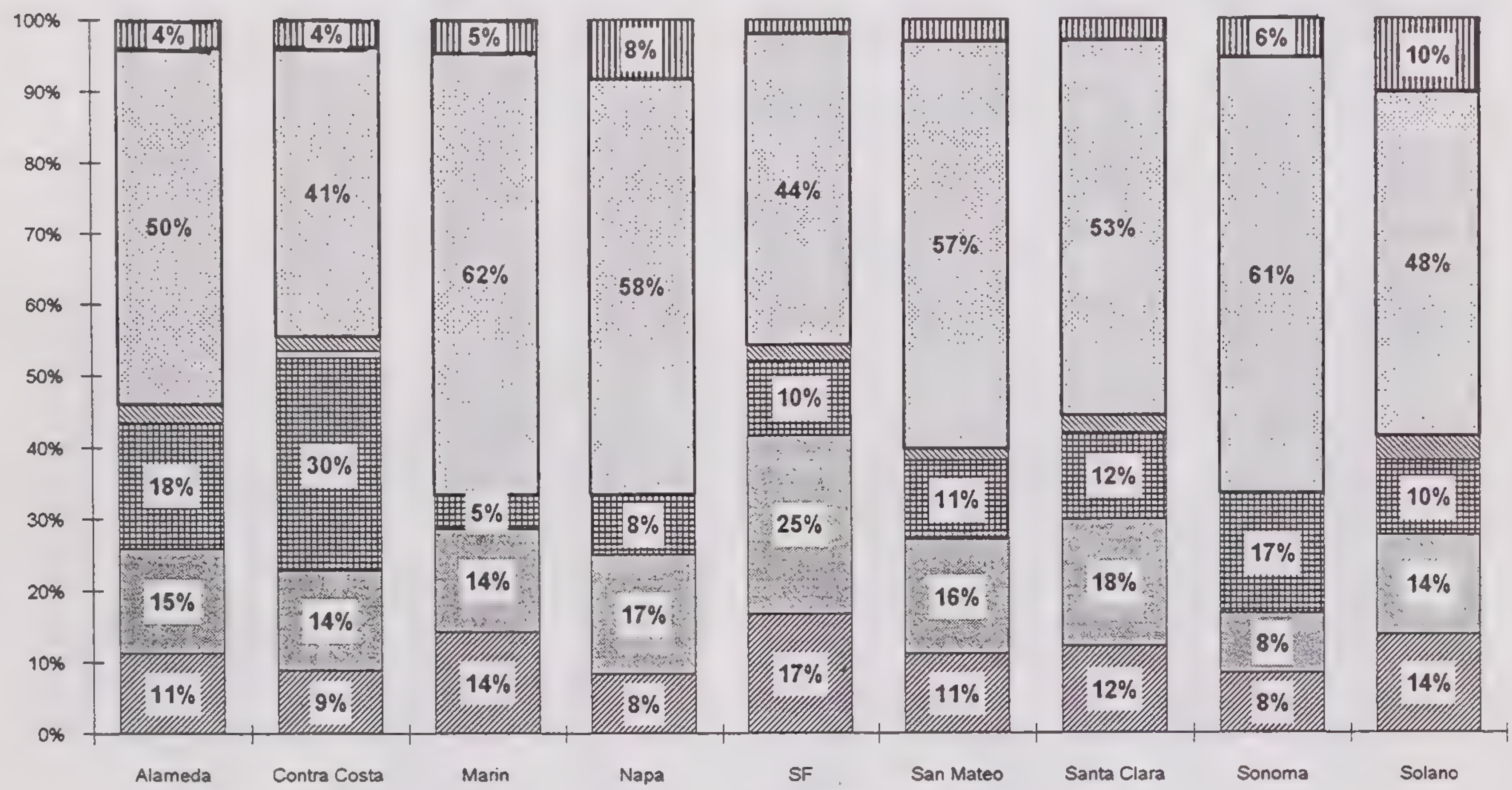


Fig. C-3-b Reactive Organics

Figure C.3 (Continued) BAY AREA EMISSION INVENTORY (1993 Annual Average) -- by COUNTY

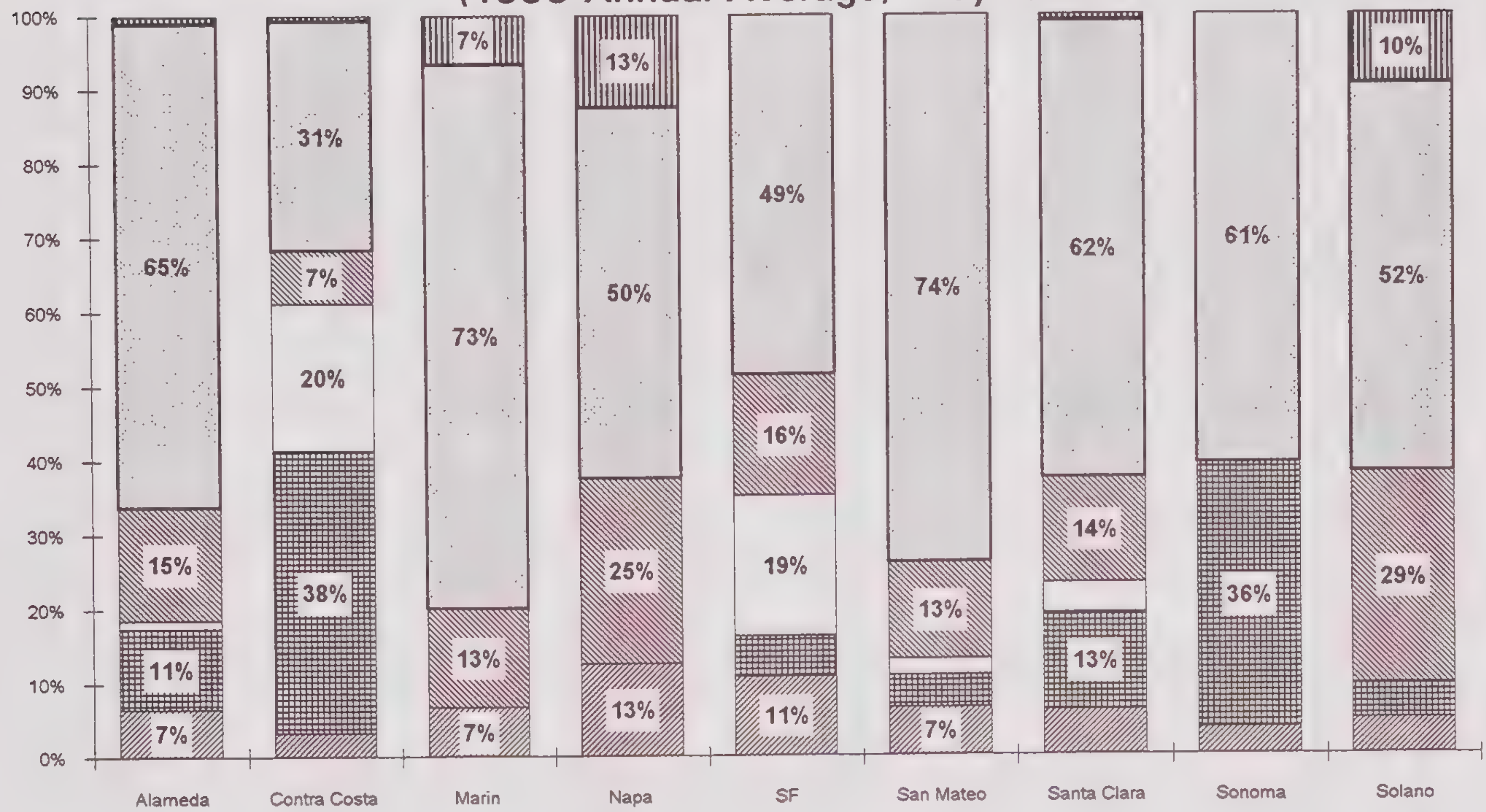


Fig. C-3-c Nitrogen Oxides

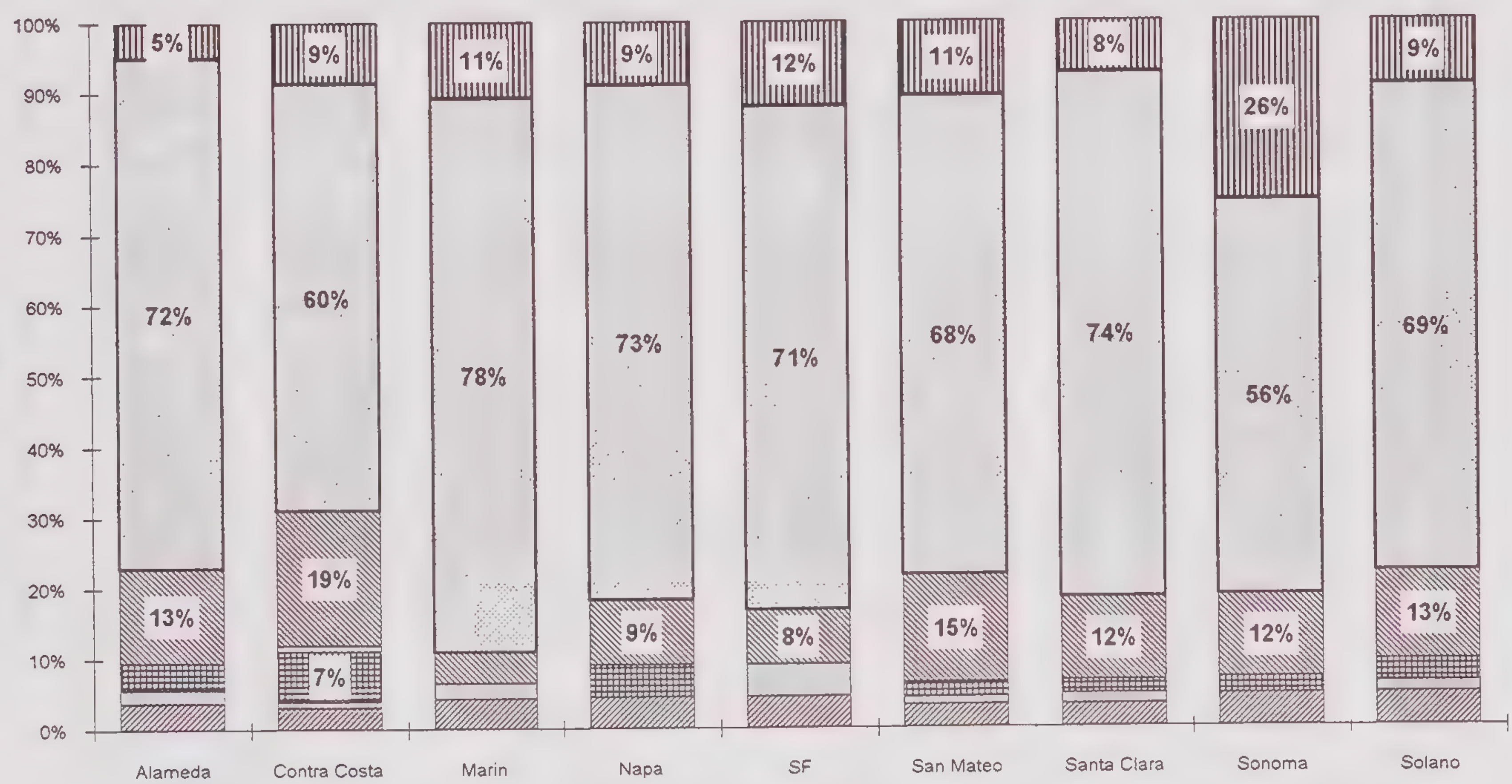


Fig. C-3-d PM-10

Legend						
Residential	Commercial	Industrial	Infrastructure	Construction	Transportation	Agriculture

Table C.IV.a EMISSION INVENTORY SUMMARY: 1995 Contaminant Levels Annual Average (Tons/Day)

	Use-Category	Alameda	Contra Costa	Marin	Napa	SF	San Mateo	Santa Clara	Solano	Sonoma	District Total
Carbon Monoxide (CO)	Residential	41	28	10	5	21	22	45	10	18	198
	Commercial	19	15	4	2	7	11	22	4	9	94
	Industrial	10	43	2	1	5	5	22	3	4	94
	Infrastructure	0	6	0	0	1	0	1	0	0	9
	Construction	52	34	8	6	22	23	52	0	16	213
	Transportation	401	263	87	46	133	217	451	103	92	1792
	Agricultural & Natural	3	3	2	2	0	1	6	0	6	24
	Total	527	392	113	63	189	278	598	120	144	2425
Reactive Organics (HC)	Residential	14	9	3	1	8	7	15	3	4	63
	Commercial	17	13	3	2	11	9	21	3	4	82
	Industrial	22	31	1	1	5	7	16	6	3	90
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	3	2	0	0	1	1	3	0	1	13
	Transportation	57	38	12	7	19	33	63	21	13	262
	Agricultural & Natural	5	4	1	1	1	2	4	2	3	23
	Total	117	96	22	13	46	59	122	35	28	535
Nitrogen Oxides (NO_x)	Residential	6	4	1	1	4	3	6	1	1	26
	Commercial	0	0	0	0	0	0	0	0	0	0
	Industrial	11	48	0	0	2	2	14	10	1	89
	Infrastructure	1	21	0	0	6	1	4	0	0	34
	Construction	13	8	2	2	5	6	13	0	5	54
	Transportation	58	37	10	4	18	33	58	17	10	245
	Agricultural & Natural	1	1	1	1	0	0	1	0	2	6
	Total	89	120	15	8	34	45	95	28	20	454
Sulfur Dioxide (SO_2)	Residential	0	0	0	0	0	0	0	0	0	1
	Commercial	0	0	0	0	0	0	0	0	0	0
	Industrial	2	44	0	0	0	0	2	14	0	63
	Infrastructure	0	0	0	0	0	0	0	0	0	1
	Construction	1	1	0	0	0	1	1	0	1	5
	Transportation	8	7	1	0	8	2	3	2	1	31
	Agricultural & Natural	0	0	0	0	0	0	0	0	0	0
	Total	12	53	1	1	9	3	6	16	1	102
Fine Particulate Matter (PM_{10})	Residential	4	3	1	1	2	2	4	1	2	17
	Commercial	2	1	1	0	2	1	2	0	1	7
	Industrial	3	5	0	1	0	1	2	1	1	14
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	12	14	2	1	3	8	14	3	5	61
	Transportation	63	42	20	9	26	35	88	14	24	321
	Agricultural & Natural	4	6	3	1	4	5	9	6	3	41
	Total	88	70	26	12	36	52	119	24	35	462

NOTES: Reactive organic (hydrocarbon or HC) tonnages exclude non-reactive hydrocarbons, such as methane and naturally occurring hydrocarbon emissions from vegetation. NOx tonnages are as NO_2. "Natural" PM_{10} includes wind-blown dust and ocean salt particles. Totals may differ slightly from sums of tabled values because of rounding. Projections are based on Base Year 1990 Air District Emission Inventory.

Table C.IV.b EMISSION INVENTORY SUMMARY: 2000 Contaminant Levels Annual Average (Tons/Day)

	Use-Category	Alameda	Contra Costa	Marin	Napa	SF	San Mateo	Santa Clara	Solano	Sonoma	District Total
Carbon Monoxide (CO)	Residential	43	29	11	5	22	23	47	10	19	208
	Commercial	15	12	3	2	6	9	18	3	7	74
	Industrial	11	46	2	1	5	6	24	3	4	102
	Infrastructure	0	7	0	0	1	0	1	0	0	11
	Construction	55	36	8	7	24	24	55	0	17	225
	Transportation	290	195	66	38	96	160	323	80	70	1318
	Agricultural & Natural	4	4	2	3	0	1	6	0	6	26
	Total	418	328	92	56	154	222	473	97	123	1963
Reactive Organics (HC)	Residential	14	9	3	1	8	7	16	3	4	65
	Commercial	15	11	3	2	10	9	19	3	3	75
	Industrial	22	31	1	1	5	7	16	5	3	91
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	3	2	0	0	1	1	3	0	1	13
	Transportation	41	28	9	6	14	25	44	18	9	194
	Agricultural & Natural	5	4	1	1	1	2	4	2	4	25
	Total	101	86	19	12	40	51	102	32	24	464
Nitrogen Oxides (NO_x)	Residential	6	4	1	1	4	3	6	1	1	26
	Commercial	0	0	0	0	0	0	0	0	0	1
	Industrial	11	50	0	0	2	2	15	11	1	93
	Infrastructure	1	25	0	0	7	1	5	0	0	39
	Construction	14	9	2	2	6	6	14	0	6	58
	Transportation	51	33	9	4	16	30	50	15	9	217
	Agricultural & Natural	1	1	1	1	0	0	1	0	2	6
	Total	85	122	14	8	34	42	90	27	19	441
Sulfur Dioxide (SO_2)	Residential	0	0	0	0	0	0	0	0	0	1
	Commercial	0	0	0	0	0	0	0	0	0	0
	Industrial	2	47	0	0	0	0	2	15	0	66
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	1	1	0	0	1	1	1	0	1	6
	Transportation	9	8	1	0	9	2	3	2	1	33
	Agricultural & Natural	0	0	0	0	0	0	0	0	0	1
	Total	12	56	1	1	10	3	7	17	1	107
Fine Particulate Matter (PM_{10})	Residential	4	2	1	1	2	2	4	1	1	18
	Commercial	1	1	1	0	1	1	1	1	1	8
	Industrial	4	5	0	1	0	1	3	1	1	15
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	13	15	2	1	2	9	16	3	5	66
	Transportation	70	46	22	10	29	39	97	15	27	355
	Agricultural & Natural	4	5	2	2	2	4	8	6	3	39
	Total	96	75	28	14	37	56	129	27	38	501

NOTES: Reactive organic (hydrocarbon or HC) tonnages exclude non-reactive hydrocarbons, such as methane and naturally occurring hydrocarbon emissions from vegetation. NOx tonnages are as NO_2. "Natural" PM_{10} includes wind-blown dust and ocean salt particles. Totals may differ slightly from sums of tabled values because of rounding. Projections are based on Base Year 1990 Air District Emission Inventory.

Table C.IV.c EMISSION INVENTORY SUMMARY: 2010 Contaminant Levels Annual Average (Tons/Day)

	Use-Category	Alameda	Contra Costa	Marin	Napa	SF	San Mateo	Santa Clara	Solano	Sonoma	District Total
Carbon Monoxide (CO)	Residential	45	31	11	5	24	24	50	11	20	222
	Commercial	7	5	2	1	3	4	8	1	3	33
	Industrial	13	51	2	1	6	6	27	3	4	113
	Infrastructure	1	7	0	0	1	0	1	0	0	10
	Construction	62	40	9	8	27	28	62	0	19	254
	Transportation	204	142	51	33	64	114	210	67	52	938
	Agricultural & Natural	4	4	3	3	0	1	7	0	7	29
	Total	336	281	77	51	124	177	365	83	106	1600
Reactive Organics (HC)	Residential	15	9	3	1	9	8	17	3	4	70
	Commercial	15	11	3	2	10	8	18	3	3	72
	Industrial	23	31	1	1	5	6	17	6	2	93
	Infrastructure	0	1	0	0	0	0	0	0	0	2
	Construction	4	2	1	0	2	2	3	0	1	15
	Transportation	26	19	6	5	8	17	25	15	6	128
	Agricultural & Natural	5	4	1	1	1	2	4	2	4	27
	Total	88	78	16	11	34	43	86	29	21	406
Nitrogen Oxides (NO_x)	Residential	6	4	1	1	4	3	6	1	1	27
	Commercial	0	0	0	0	0	0	0	0	0	1
	Industrial	13	52	1	1	2	2	17	11	1	100
	Infrastructure	1	23	0	0	6	1	5	0	0	37
	Construction	16	10	2	2	6	7	15	0	6	65
	Transportation	51	32	9	4	15	29	48	16	9	212
	Agricultural & Natural	1	1	1	1	0	0	1	0	2	7
	Total	88	122	14	8	33	42	93	28	20	449
Sulfur Dioxide (SO_2)	Residential	0	0	0	0	0	0	0	0	0	1
	Commercial	0	0	0	0	0	0	0	0	0	0
	Industrial	2	48	0	0	0	0	2	15	0	68
	Infrastructure	0	1	0	0	1	0	0	0	0	1
	Construction	2	1	0	0	1	1	1	0	1	6
	Transportation	10	9	1	0	10	2	3	2	1	37
	Agricultural & Natural	0	0	0	0	0	0	0	0	0	1
	Total	14	58	1	1	11	3	7	17	2	115
Fine Particulate Matter (PM_{10})	Residential	4	3	1	1	2	1	4	1	2	18
	Commercial	2	1	1	0	2	1	2	1	1	11
	Industrial	4	5	0	1	1	2	3	1	1	17
	Infrastructure	0	1	0	0	0	0	0	0	0	1
	Construction	14	16	2	2	3	10	17	4	6	73
	Transportation	84	56	27	12	35	46	114	18	32	423
	Agricultural & Natural	4	6	2	1	3	5	9	6	3	40
	Total	112	89	32	16	45	65	149	30	46	582

NOTES: Reactive organic (hydrocarbon or HC) tonnages exclude non-reactive hydrocarbons, such as methane and naturally occurring hydrocarbon emissions from vegetation. NOx tonnages are as NO_2. "Natural" PM_{10} includes wind-blown dust and ocean salt particles. Totals may differ slightly from sums of tabled values because of rounding. Projections are based on Base Year 1990 Air District Emission Inventory.

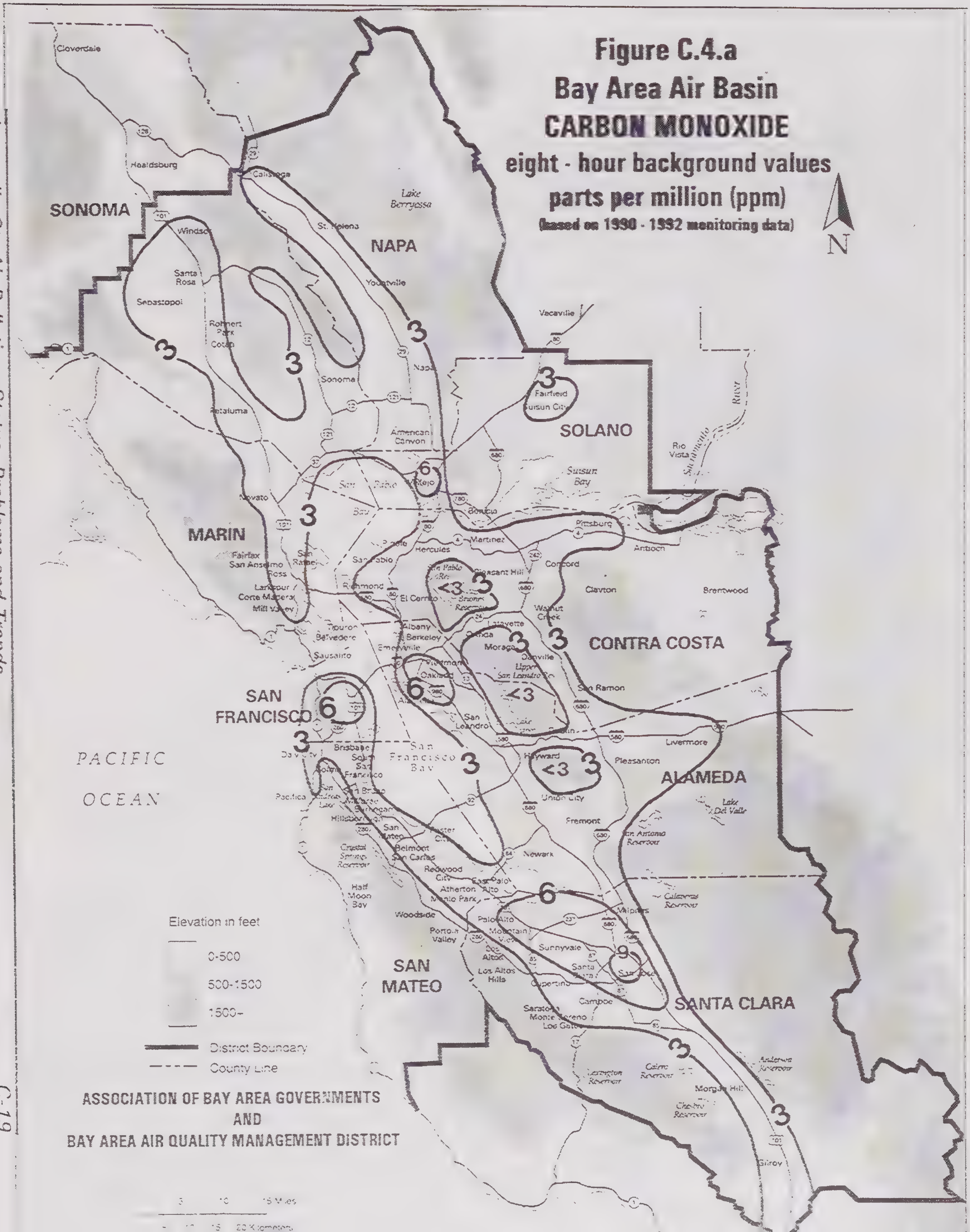


Figure C.4.a
Bay Area Air Basin
CARBON MONOXIDE
eight - hour background values
parts per million (ppm)
(based on 1990 - 1992 monitoring data)
N
SONOMA
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
PACIFIC OCEAN
Elevation in feet
0-500
500-1500
1500+
District Boundary
County Line
ASSOCIATION OF BAY AREA GOVERNMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

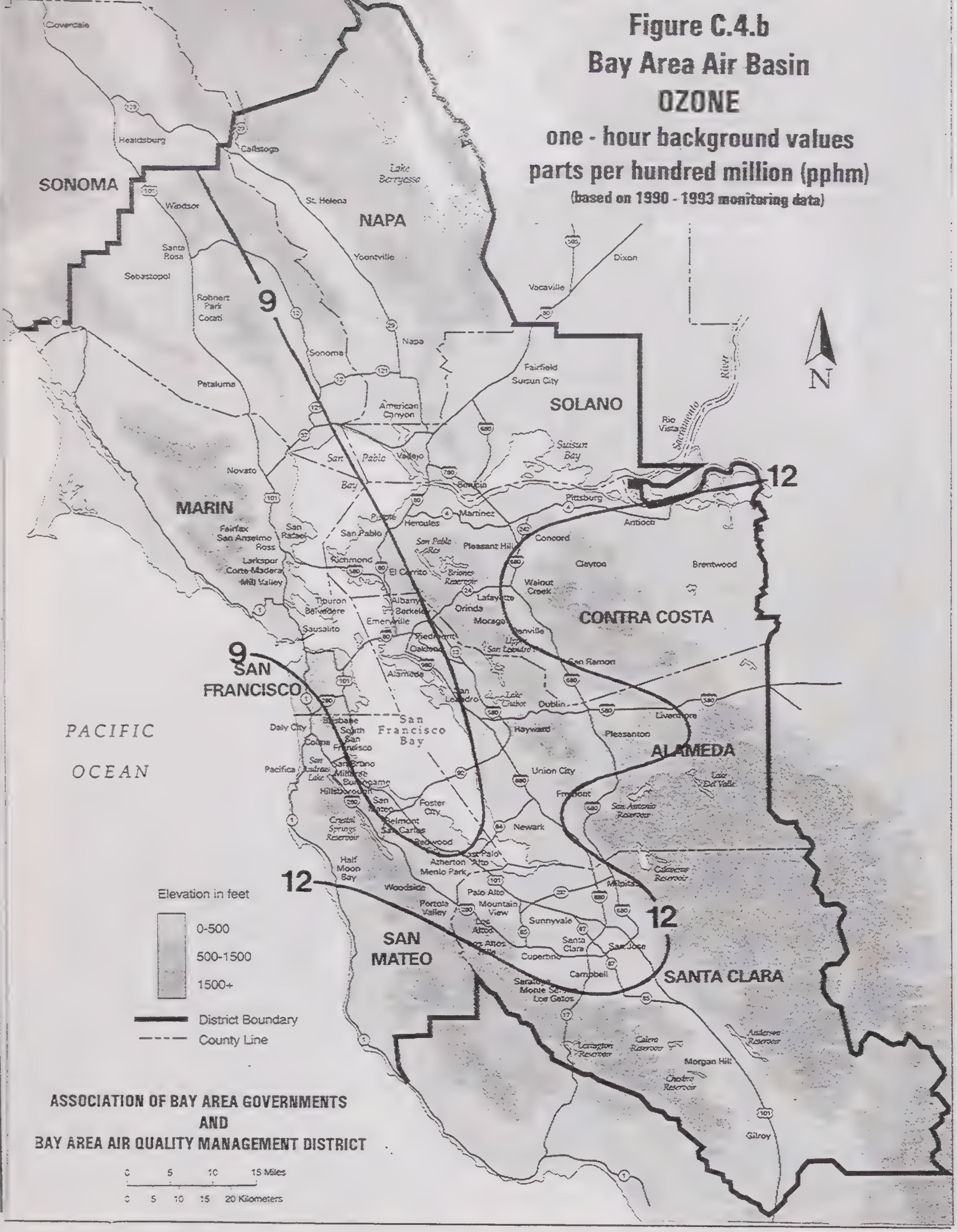


Figure C.4.b
Bay Area Air Basin
OZONE
one - hour background values
parts per hundred million (pphm)
(based on 1990 - 1993 monitoring data)


Figure C.4.c
Bay Area Air Basin
FINE PARTICULATE MATTER (PM_{10})
24 - hour background values
micrograms per cubic meter ($\mu g/m^3$)
(based on 1990 -1992 monitoring data)
SONOMA
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
PACIFIC OCEAN
San Pablo Bay
San Francisco Bay
Suisun Bay
110
100
90
120
130
140
N
Elevation in feet
0-500
500-1500
1500-
District Boundary
County Line
ASSOCIATION OF BAY AREA GOVERNMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT
0 5 10 15 Miles
0 5 10 15 20 Kilometers

APPENDIX D: CLIMATE, TOPOGRAPHY, AND AIR POLLUTION POTENTIAL

Appendix D provides climatological and topographic information about the Bay Area and its subregions. It also explains how these natural conditions influence the potential for air pollution problems. The first two sections address region-wide conditions which are relevant to all cities and counties in the Bay Area. The final two sections discuss climatological subregions, referenced by county; local planners should select and use the subsections appropriate to their interests. (See Table D.1 and Figure D.1.)

Bay Area Climate and Topography

High Pressure Cell

During the summer, the large-scale meteorological condition that dominates the West Coast is a semipermanent high pressure cell centered over the northeastern Pacific Ocean. This high pressure cell keeps storms from affecting the California coast. Hence, the Bay Area experiences little precipitation in the summer months. In addition, winds tend to blow on shore out of the north/northwest, due to the clockwise motion of air around the high pressure area.

The steady northwesterly flow around the eastern edge of the Pacific high pressure cell exerts a stress on the ocean surface along the coast inducing upwelling of cold water from below. This upwelling produces a band of cold water that is approximately 80 miles wide off the California coast. When air approaches the California coast, already cool and moisture-laden from its long trajectory over the Pacific, it is further cooled as it crosses this bank of cold water. This cooling is often sufficient to produce condensation resulting in a high incidence of fog and stratus clouds along the Northern California coast in the summer months.

Generally in the winter, the Pacific high weakens and shifts southward, winds tend to flow offshore, upwelling ceases, and storms occur. During the winter rainy periods, inversions are weak (layers of warmer air over colder air; see section below) or nonexistent, winds are usually moderate and air pollution potential is low. The Pacific high does periodically become dominant however, bringing strong inversions, light winds and high pollution potential.

Topography

Bay Area topography is characterized by complex terrain, consisting of coastal mountain ranges, inland valleys and bays (Figure D.4). This complex terrain, especially the higher elevations, distort the normal wind flow patterns in the Bay Area. The highest amount of distortion occurs when low-level inversions are present and the air beneath the inversion flows independently of air above the inversion — a condition that is common in the summer time.

The only major break in California's Coast Range occurs in the Bay Area; here the Coast Range splits into western and eastern ranges. Between the two ranges lies San Francisco Bay. The gap in the western coast range is known as the Golden Gate, and the gap in the eastern coast range is the Carquinez Strait. These gaps were originally cut by rivers flowing out of the Sierra Nevada mountains. Aside from allowing water to flow to the ocean, these gaps allow air to pass into and out of the Bay Area and the Central Valley.

Wind Patterns

During the summer months, winds flowing from the northwest are drawn inland through the Golden Gate and over the lower portions of the San Francisco Peninsula. Immediately to the south of Mount Tamalpais, the northwesterly winds accelerate considerably and come more directly from the west as they stream through the Golden Gate. This channeling of the flow of wind through the Golden Gate produces a jet that sweeps eastward and splits off to the northwest toward Richmond and to the southwest toward San Jose when it meets the East Bay hills.

Wind speeds may be strong locally in regions where air is channeled through a narrow opening, such as the Carquinez Strait, the Golden Gate, or the San Bruno gap (an area of lower elevation, surrounded by low hills, that stretches from San Bruno to the Pacific ocean). For example, the average wind speed at San Francisco International Airport in July is about 17 knots (from 3 p.m. to 4 p.m.), compared with only 7 knots at San Jose and less than 6 knots at the Farallon Islands.

The air flowing in from the coast to the Central Valley, called the sea breeze, begins developing at or near ground level along the coast in late morning or early afternoon. As the day progresses, the sea breeze layer deepens and increases in velocity while spreading inland. The depth of the sea breeze depends in large part upon the height and strength of the inversion. If the inversion is low and strong, and hence stable, the flow of the sea breeze, or marine air, will be inhibited and stagnant conditions are likely to result.

In the winter season, the Bay Area frequently experiences stormy conditions with moderate to strong winds as well as periods of stagnation with very light winds. Winter stagnation episodes are characterized by nighttime drainage flows in coastal valleys. Drainage is a reversal of the usual daytime air-flow patterns; air moves from the Central Valley toward the coast and back down toward the Bay from the smaller valleys within the Bay Area. Figure D.2 illustrates the most prevalent regional wind patterns in the Bay Area; one of the schematic maps, labeled Bay Inflow, illustrates the phenomenon of drainage.

Temperature

The summertime distribution of temperatures in the Bay Area is determined in large part by the effect of differential heating between land and water surfaces. Because land tends to heat up and cool off more quickly

than water, a large-scale gradient (differential) in temperature is often created between the coast and the Central Valley and small-scale local gradients are often produced along the shorelines of the ocean and bays. The temperature gradient near the ocean is also exaggerated, especially in summer, because of the upwelling phenomenon along the coast off the Bay Area, cold ocean bottom water comes to the surface and cools the air passing over it. This circumstance is a major cause of summer fog at and near the ocean. Thus, on summer afternoons the temperatures at the coast can be 35°F cooler than temperatures 15 to 20 miles inland. At night this contrast usually decreases to less than 10°.

In the winter, the relationship of minimum and maximum temperatures is reversed. During the daytime the temperature contrast between the coast and inland areas is small, whereas at night the variation in temperature is large.

Precipitation

The Bay Area is characterized by moderately wet winters and dry summers. Winter rains (December through March) account for about 75 percent of the average annual rainfall. The amount of annual precipitation can vary greatly from one part of the Bay Area to another even within short distances. In general, total annual rainfall can reach 40 inches in the mountains, but it is often less than 16 inches in sheltered valleys. The frequency of winter rain is more uniform, however, with ten days per month being the norm.

During rainy periods, ventilation (rapid horizontal movement of air and injection of cleaner air) and vertical mixing are usually high, and thus pollution levels tend to be low. However, frequent dry periods do occur during the winter where mixing and ventilation are low and pollutant levels build up.

Air Pollution Potential

The potential for high pollutant concentrations developing at a given location depends upon the quantity of pollutants emitted into the atmosphere in the surrounding area or upwind, and the ability of the atmosphere to disperse the contaminated air. The topographic and climatological factors discussed above generally influence the atmospheric pollution potential of an area. Atmospheric pollution potential, as the term is used here, is independent of the location of emission sources and is instead a function of factors described below.

Wind Circulation

Low wind speed contributes to the buildup of air pollution because it allows more pollutants to be emitted into the air mass per unit of time. Light winds occur most frequently during periods of low sun (fall and winter — and early morning all year) and no sun (nighttime). Unfortunately, these are also periods when emissions from some pollutant sources are at their peak, namely, commute traffic (early morning) and the use of wood burning appliances (nighttime). The problem can be

compounded in valleys, when weak flows carry the pollutants upvalley during the day, and cold air drainage flows move the air mass downvalley at night. Such sloshing of trapped air provides little opportunity for ventilation (entrance of fresh air and dilution) and leads to the buildup of pollutants to potentially unhealthful levels. (This process, as related to Bay Area topography, is discussed further in the section below on sheltered terrain.)

Wind-roses (Figure D.3) provide information useful to planners for communities that contain industries, landfills and other potentially odorous or noxious land uses. Each wind-rose diagram provides a general indication of the proportion of time that winds blow from each compass direction; the longer the vector length, the greater the frequency of wind occurring from that direction. Such information may be particularly useful in planning land-use relationships and buffer zones. For example, a residential development, school or hospital is likely to be an inappropriate use immediately downwind from an industry which has the potential to emit toxic or odorous gases or particulate matter. Facilities which house sensitive users are especially inappropriate if the wind blows frequently from the industrial site — unless an adequate separation is provided by a buffer zone. Caution should be taken, however, in using wind-roses in the planning process. A site on the opposite side of a hill or tall building, even a short distance from a meteorological monitoring station, may experience a significant difference in wind pattern. Figure D.3 is a map of simplified wind roses, composed of data from a number of Bay Area meteorological stations.

Inversions

A primary factor affecting air quality is the mixing depth, i.e., the vertical depth in the atmosphere available for diluting air contaminants near the ground. In the Bay Area, the frequent occurrence of elevated temperature inversions in summer and fall months acts to cap the mixing depth and consequently limit the depth of air available for dilution. An inversion is a layer of warmer air over a layer of cooler air. Elevated inversions are caused by subsiding air from the subtropical high pressure zone, and from the cool marine air layer that is drawn into the Bay Area by the heated low pressure region in the Central Valley.

The inversions typical of winter, called radiation inversions, are formed as heat quickly radiates from the earth's surface after sunset, causing the air in contact with it to rapidly cool. It is on clear, low-wind-speed, cold winter nights that radiation inversions are the strongest, allowing the build-up of such pollutants as carbon monoxide and particulate matter. When wind speeds are low, there is little mechanical turbulence to mix the air, resulting in a layer of warm air over a layer of cooler air next to the ground. Mixed depths under these conditions can be as shallow as 50 to 100 meters, particularly in rural areas. Urban areas usually have deeper minimum mixed layers because of heat island effects and increased surface roughness. Under these conditions the downwind transport is slow, the mixing depths are shallow, and the turbulence is minimal. All of these factors contribute to increased pollution levels in the surface layers.

Although each type of inversion is most common during a specific season, either inversion mechanism can occur at any time of the year. Sometimes both occur simultaneously. Moreover, the characteristics of an inversion often change throughout the course of a day. The terrain of the Bay Area also induces significant variations among subregions.

Stability

Stability is defined as the atmosphere's resistance to vertical motions. The more stable the air, the slower the mixing, resulting in increased probability for air pollutants to build up and exceed ambient air quality standards.

The stability of the atmosphere is highly dependent upon the vertical distribution of temperature with height. When the temperature decreases in the vertical dimension ("lapse rate") at 10 degrees Celsius per 1000 meters, the atmosphere is classified as "neutral stability". When the lapse rate is greater than 10 degrees C per 100 meters, the atmosphere is "unstable". If the lapse rate is less than 10 degrees per 1000 meters, or the temperature increases with height, the atmosphere is "stable". These stabilities have been categorized for use in dispersion models. Alphabet categories run from A to — and including — F, ranging from "Extremely Unstable" (Stability Class A), through "Neutral" (D), to "Stable" (F).

Unstable conditions can only occur during daytime hours when solar heating is able to warm the lower layers sufficiently to get a strong lapse rate. Under A stability conditions, large horizontal wind direction fluctuations occur, along with large vertical mixing. These motions usually only occur midday during summer months on cloudless days with light winds. Under B stability conditions, wind direction fluctuations and vertical mixing are less pronounced, because the heating is less strong. The fluctuations found during both A and B stability conditions are mostly due to thermal turbulence. Under C stability conditions, the solar insulation is weaker, or the wind speeds are stronger, so that the surface heating is weaker. The horizontal and vertical fluctuations are weaker yet, and are due to a combination of thermal and mechanical turbulence.

D stability can occur either during the day or at night. Under D stability conditions, the wind speeds are usually strong — greater than 5 meters per second — or the sky is obscured by clouds. Wind direction fluctuations are small, while vertical motions are primarily generated by mechanical turbulence.

Stabilities E and F can only occur at night. The appropriate lapse rate conditions can only occur in the absence of sunlight, and with light to moderate winds; strong winds would mix the air and make the lapse rate neutral. Under these conditions, there is little turbulence because of the atmosphere's resistance to vertical motion. Pollutants emitted into a stable air mass will travel downwind with little dispersion.

Solar Radiation

The frequency of hot, sunny days during the summer months in the Bay Area is another important factor that

affects air pollution potential. It is at the higher temperatures that ozone is formed. In the presence of ultraviolet sunlight and warm temperatures, hydrocarbons and oxides of nitrogen react to form secondary photochemical pollutants, including ozone. Because temperatures in many of the Bay Area inland valleys are so much higher than near the coast, the inland areas are especially prone to photochemical air pollution.

In late fall and winter, solar angles are low, resulting in insufficient ultraviolet light and warming of the atmosphere to drive the photochemical reactions. Consequently, ozone concentrations do not reach significant levels in the Bay Area during these seasons.

Sheltered Terrain

The mountains surrounding the Bay Area contribute to the high pollution potential of some areas. During the day, or at night during windy conditions, areas in the lee of mountains are sheltered from the prevailing winds, thereby reducing turbulence and downwind transport. At night, when wind speeds are low, the upper atmospheric layers are often decoupled from the surface layers during radiation conditions. Where elevated terrain is situated, it will tend to block pollutant transport in that direction. Additionally, elevated terrain can create a recirculation pattern by inducing upvalley air flows during the day and reverse downvalley flows during the night, allowing little inflow of fresh air.

The areas having the highest air pollution potential tend to be those that experience the highest temperatures in the summer and the lowest temperatures in the winter. Bay Area coastal areas are exposed to the prevailing marine air and consequently have cooler temperatures in the summer, warmer temperatures in winter, and experience stratus clouds all year. The inland valleys are sheltered from the marine air and consequently, experience a more continental climate — hotter summers and colder winters. Thus, the topography of the inland valleys creates conditions conducive to high air pollution potential.

Pollution Potential Related to Emissions

Although air pollution potential is most strongly influenced by atmospheric factors, the air pollution that actually occurs in any location also depends upon the density of pollutant emissions in the surrounding area — or that transported from more distant places. Pollutant emission densities are generally highest in areas that have high population densities, intensive vehicle use and/or industrialization; however, high concentrations of contaminants created by chemical processes in the atmosphere — such as ozone — may occur many miles downwind from the sources of their precursor chemicals.

Climatological Subregions

This section discusses the varying climatological and topographic conditions — and the resulting variations in air pollution potential — within the inhabited subregions of the Bay Area Air Basin . All urbanized areas of the Bay Area are included in one of 11 subregions; sparsely

inhabited mountainous areas — such as central Marin County and eastern Santa Clara County — and large parks — such as the Point Reyes National Seashore — are excluded from the subregional designations. The 11 subregions are portrayed in Figure D.1.

The information about each subregion includes location, topography, and climatological factors relevant to air quality — often separated into summer and winter conditions which differ in terms of pollution problems. Where relevant to air quality concerns, more localized subareas within a subregion are differentiated in the discussion. Each subregional section concludes with a discussion of pollution potential resulting from climatological and topographic variables and the major types of sources of contaminant emissions in the subregion. Where relevant, there is also brief discussion of pollutant transport to and from other subregions in the Bay Area and/or neighboring regions such as the San Joaquin Valley.

Carquinez Strait Region

The Carquinez Strait, from one-half to one-and-one-half miles wide, runs from Davis Point in Rodeo to Martinez. It is the only sea-level gap between San Francisco Bay and the Central Valley of California. The term "Carquinez Strait Region" refers to the Bay Area subregion that includes the lowlands bordering the strait to the north and south. This subregion also includes the area adjoining Suisan Bay and the western part of the Sacramento-San Joaquin Delta as far east as Bethel Island. The subregion discussed in this section extends from Rodeo in Contra Costa County on the southwest and Vallejo in the northwest to Fairfield on the northeast and Brentwood on the southeast.

Prevailing winds are from the west in the Carquinez Strait. During the summer and fall months, high pressure offshore coupled with low pressure in the Central Valley sets up a pressure pattern that draws marine air eastward through the Carquinez Strait. The wind is strongest in the afternoon, when the pressure gradient (differential) between the eastern Pacific high and the inland thermal low is greatest. Afternoon wind speeds of 15 to 20 mph are common throughout the strait region due to the wind tunnel effect of the surrounding hills. Annual average wind speeds are 8 mph in Martinez, and 9 to 10 mph further east.

On occasion, the high pressure cell is centered over the Great Basin or the Pacific Northwest, which sets up an east to west or northeast to southwest pressure gradient and causes air to flow from the east. In the summer and fall months, this can cause elevated pollutant levels to move into the Bay Area through the strait. These high pressure periods are usually accompanied by low wind speeds, shallow mixing depths, and little or no rainfall. Furthermore, the air mass from the east is warmer — the July mean maximum temperature reaches about 90° F. at the eastern end of the subregion. Temperature extremes are especially pronounced in sheltered subareas more distant from the moderating effects of the strait itself, e.g. at Fairfield. In addition, east winds usually contain more pollutants than the cleaner marine air from the west.

Many industrial facilities that have significant emissions — e.g., chemical plants and refineries — are located within the Carquinez Strait Region In general, the pollution potential of this area is often moderated by high wind speeds. However, upsets at the industrial facilities can lead to short-term pollution episodes. Receptors downwind of these facilities could suffer more long-term exposure to air contaminants than individuals elsewhere. Consequently, it is important that local governments require that facilities maintain reasonably large buffers zones downwind of their sources. The problem is most frequent for receptors to the east of high polluting facilities because the winds are most common from the west. However, buffer zones should be provided wherever it is possible around polluting industries because, as shown in the wind rose map (Figure D.3), there is some wind, at some time, from all points of the compass.

Areas of the subregion that are traversed by major roadways — e.g. I - 80 — may also be subject to local concentrations of carbon monoxide and particulate matter.

Cotati and Petaluma Valleys

The subregion that stretches from Santa Rosa all the way to the San Pablo Bay is often considered as two different valleys: the Cotati Valley in the north and the Petaluma Valley in the south. The largest city in the Cotati Valley is Santa Rosa; the largest city in the Petaluma Valley is Petaluma. To the east, the valley is bordered by the Sonoma Mountains, while to the west is a series of low hills, followed by the Estero Lowlands, which open to the Pacific Ocean. The region from the Estero Lowlands to the San Pablo Bay is known as the Petaluma Gap. This low-terrain area allows marine air to travel into the Bay Area.

Wind patterns in the Petaluma and Cotati Valleys are strongly influenced by the Petaluma Gap, with winds flowing predominantly from the west. As marine air travels through the Petaluma Gap, it splits into northward and southward paths moving into the Cotati and Petaluma valleys. The southward path crosses San Pablo Bay and moves eastward through the Carquinez Strait. The northward path contributes to Santa Rosa's prevailing winds from the south and southeast. Petaluma's prevailing winds are from the northwest.

When the ocean breeze is weak, strong winds from the east can predominate, carrying pollutants picked up in the Central Valley and the Carquinez Strait. During these periods, upvalley flows can carry the polluted air as far north as Santa Rosa.

Winds are usually stronger in the Petaluma Valley than the Cotati Valley because the former is directly in line with the Petaluma Gap. Consequently, Petaluma's climate is similar to areas closer to the coast even though Petaluma is 28 miles from the ocean. Average annual wind speed at the Petaluma Airport is seven mph. The Cotati Valley, being slightly north of the Petaluma Gap, experiences lower wind speeds; in Santa Rosa, the annual average wind speed is five mph.

Because the distance across the Petaluma Gap is long, marine air is warmed and any fog evaporates before it reaches the Petaluma and Cotati Valleys. When surface heating weakens in the late afternoon, as the sun gets lower in the sky, the marine layer becomes less heated and fog forms in the valleys during the evening.

Rainfall averages are 24 inches per year at Petaluma and 30 inches at Santa Rosa. Santa Rosa's rainfall is greater because of its proximity to the Sonoma Mountains. Air is lifted and cooled in advance of the Sonoma Mountains, which causes condensation. Consistent with the Bay Area's Mediterranean climate, Santa Rosa and Petaluma receive more than 80 percent of their annual rainfall from November through March.

Air temperatures are very similar in the two valleys. Summer maximum temperatures for this region are in the low-80's, while winter maximum temperatures are in the high-50's to low-60's. Summer minimum temperatures are around 50 degrees, and winter minimum temperatures are in the high 30's.

Generally, air pollution potential is low in the Petaluma Valley because of its link to the Petaluma Gap and because of its low population density. However, there are two scenarios that could produce elevated pollutant levels: (1) stagnant conditions in the morning hours created when a weak ocean breeze meets a weak bay breeze and (2) pollution brought in from the Carquinez Strait Region and the Central Valley in the afternoon by an eastern or southeastern wind pattern.

The Cotati Valley has a higher pollution potential than does the Petaluma Valley. The Cotati Valley lacks a gap to the sea, contains a larger population, and has natural barriers at its northern and eastern ends. There are also industrial facilities in and around Santa Rosa.

Both valleys of this subregion are also threatened by increased motor vehicle traffic and the air contaminants it generates. Not only are local population and vehicle trips on the increase, but the differential in housing costs and the suburbanization of employment are leading to more and longer commutes traversing the subregion.

Diablo and San Ramon Valleys

East of the Coast Range lies the Diablo and San Ramon Valleys. The valleys have a northwest to southeast orientation, with the northern portion known as Diablo Valley and the southern portion as San Ramon Valley. The Diablo Valley is a broad valley, approximately 5-miles wide and 10-miles long that is bordered in the north by the Carquinez Strait and in the south by the San Ramon Valley. The major cities in the Diablo Valley are Concord and Walnut Creek.

San Ramon Valley extends south from Walnut Creek to Dublin. The valley is long and narrow, approximately 12-miles long and one-mile wide. At its southern end it opens onto the Amador Valley. Its major towns are Danville and San Ramon.

The mountains of the Coast Range on the west side of these valleys are 1500 to 2000 feet high, this is high

enough to block much of the marine air from reaching the valleys. During the daytime, there are two predominant flow patterns: an upvalley flow from the north and a westerly flow (wind from the west) across the lower elevations of the Coast Range. On clear nights, surface inversions separate the flow of air into two layers: the surface flow and the upper layer flow. When this happens, there are often drainage surface winds which flow downvalley toward the Carquinez Strait.

Wind speeds in these valleys rank as some of the lowest in the Bay Area. For example, the monitoring stations in Concord and Danville report annual average wind speeds of 5 mph. However, winds can increase in the afternoon near the town of San Ramon because it is located at the eastern edge of the Crow Canyon gap. Through this gap, polluted air from cities near the bay travels across Hayward to the valley in the summer months.

Air temperatures in these valleys are cooler in the winter and warmer in the summer than are temperatures further west. These valleys are far from the moderating effect of the bay and ocean — and the Coast Range blocks marine air flow.

These two valleys rarely experience fog during the summer, but in the winter, tule fogs are common. Tule fogs form on cold, clear nights when winds are light and there is abundant moisture on the ground, as happens after a rainstorm. Tule fog can also be transported from the Central Valley through the Carquinez Strait and the Livermore Valley. These fogs usually burn off during the day, but occasionally can last for a week or two before being dissipated by a storm system. Shielded by the Coast Range to the west, the Diablo and San Ramon Valleys have relatively low rainfall.

Pollution potential is relatively high in these valleys. On winter evenings, light winds coupled with surface-based inversions and terrain that restricts air flow can cause pollutant levels to build up. San Ramon Valley, being very narrow, could easily experience high pollution concentrations due to motor vehicle emissions and emissions from fireplaces and wood stoves. In the summer months, ozone is often transported into the valleys from both the central Bay Area and the Central Valley.

Livermore Valley

The Livermore Valley is a sheltered inland valley near the eastern border of the District. The western side of the valley is bordered by 1,000 to 1,500 foot hills with two gaps connecting the valley to the San Francisco Bay Area — the Hayward Pass at the north and Niles Canyon at the south. The eastern side of the valley also has 1000 to 1500 foot hills, the Altamont Hills, with one major passage to the San Joaquin Valley called the Altamont Pass and several secondary passages: Kellogg Creek, Patterson Pass and Corral Hollow. To the north lie the Black Hills and Mount Diablo. A northwest to southeast channel connects the Diablo Valley to the Livermore Valley and splits the Diablo Range into eastern and western sections. The south side of the Livermore Valley is bordered by mountains that are approximately 3000 to 3500 feet high.

During the summer months, when there is a strong inversion with a low ceiling, air movement is weak and pollutants become trapped and concentrated. Maximum summer temperatures in the Livermore Valley range from the high-80's to the low-90's, with extremes in the 100's. There is little rainfall to flush out pollutants in the summer. At other times in the summer, a strong Pacific high pressure cell from the west, coupled with hot inland temperatures causes a strong onshore pressure gradient which translates into a strong, afternoon wind. With a weak temperature inversion, air moves over the hills with ease, dispersing pollutants.

In the winter, with the exception of an occasional storm moving through the area, air movement is often dictated by local conditions. At night and early morning, especially on clear, calm, and cold nights, gravity drives cold air downward (cold air is heavier than warm air); the cold air drains off the hills and moves into the gaps and passes. During the day, if the surface of the Livermore Valley is sufficiently heated, a thermally developed low pressure field can draw air through the gaps and passes and into the valley itself.

On the eastern side of the valley the prevailing winds blow from north, northeast and east out of the Altamont Pass. Winds are light during the late night and early morning hours; about 40 percent of the winds are less than 3 mph. A secondary, prevailing wind direction group, east-southeast through south-southwest is associated with daytime air flow through the Altamont Pass on its way to the San Joaquin Valley, accompanied by winter storms. Winter minimum temperatures average some ten degrees lower in the Livermore Valley than on the coast. Maximum temperatures range from the high-50's to the low-60's, while minimum temperatures are from the mid-to-high-30's, with extremes in the high teens and low-20's. The average rainfall in the winter is 14 inches.

In the Livermore Valley, air pollution potential is high, especially for photochemical pollutants in the summer and fall. High temperatures increase the potential for ozone to build up. The valley not only traps locally generated pollutants but can be the receptor of ozone and ozone precursors from San Francisco, Alameda, Contra Costa and Santa Clara counties. On northeasterly wind flow days, most common in the early fall, ozone may be carried west from the San Joaquin Valley to the Livermore Valley.

During the winter, the sheltering effect of the valley, its distance from moderating water bodies, and the presence of a strong high pressure system contribute to the development of strong, surface-based temperature inversions. Pollutants such as carbon monoxide and particulate matter can become concentrated — generated by automobiles, fireplaces and agricultural burning. Air pollution problems could intensify because of population growth and increased commuting to and through the subregion — e.g. the heightening commute pattern between the Bay Area and the San Joaquin Valley.

Marin County Basins

Marin County is bounded on the west by the Pacific Ocean, on the east by San Pablo Bay, on the south by the Golden Gate, and on the north by the Petaluma Gap. Although there are a few small towns near the ocean, most of Marin's population lives in the eastern part of the county, in small, sheltered valleys. These valleys act like a series of miniature air basins.

Although there are a few mountains above 1500 feet, most of the terrain is only 800 to 1000 feet high. Much of the time, this is not high enough to block the marine layer, which averages 1700 feet in depth. Because of the wedge shape of the county, northeast Marin County is further from the ocean than is its southeastern section. This extra distance from the ocean allows the marine air to be moderated by bayside conditions as it travels to northeastern Marin County. In southern Marin the distance from the ocean is short and elevations are lower, resulting in higher incidence of maritime air in that area.

Wind speeds are highest along the west coast of Marin, averaging about 8 to 10 miles per hour. Again, although most of the terrain in central Marin is not high enough to act as a barrier to marine air, the complex terrain creates sufficient friction to slow the air flow. Downwind, at Hamilton Air Force Base, in northeastern Marin County, the annual average wind speeds are only 5 mph. The prevailing wind directions throughout Marin County show little variation and are generally from the northwest.

In the summer months, areas along the coast are usually subject to an onshore movement of marine air; this air has been cooled as it passes over the offshore upwelling region — where the colder bottom water of the ocean has come to the surface. In the winter, proximity to the ocean keeps the coastal regions relatively warm, with temperatures varying little throughout the year. Temperatures are usually in the high-50's in the winter and the low-60's in the summer. The warmest months are September and October.

The eastern side of Marin County has warmer weather than the western side in large part because of its distance from the ocean. It is also warmer because the hills that separate eastern Marin from western Marin occasionally block the flow of the marine air. The temperatures of cities next to the bay are moderated by the cooling effect of the bay in the summer and the warming effect of the bay in the winter. For example, San Rafael experiences average maximum winter temperatures in the high-50's to low-60's and average maximum summer temperatures in the high-70's to low-80's. Inland towns such as Kentfield, on the other hand, experience average maximum temperatures that are two degrees cooler in the winter and two degrees warmer in the summer.

The mountainous terrain in Marin County results in significantly higher annual rainfall than most other parts of the Bay Area. A layer of fog is formed along the coast due to the rapid cooling of the air as it passes over the upwelling region of the ocean just off the coast. Because the moist air loses some of its moisture as it rises over the

hills, rainfall amounts near Mt. Tamalpais are twice as high as the rest of the Bay Area; San Rafael reports an average of 38 inches per year and Kentfield reports 49 inches per year. Further from the highest hills and further from the moist air corridor through the Golden Gate, Hamilton Airforce Base reports about 25 inches annually. Consistent with the Bay Area's Mediterranean climate, 84 percent of the annual rainfall in Marin occurs November through March.

Air pollution potential is highest in eastern Marin County where most of population is located in semi-sheltered valleys. In the southeast, where distances to the ocean are short, the influence of marine air keeps pollution levels low. However, as development moves further north — e.g., as Novato grows — there is greater potential for air pollution to build up because the valleys are more sheltered from the sea breeze.

While Marin County does not have many polluting industries, the air quality on its eastern side — especially along the U.S. 101 corridor — may be affected by motor vehicle emissions from a growing commute pattern to and through the county.

Napa Valley

The Napa Valley is nestled between the Mayacamas Mountains to the west and the Vaca Mountains to the east. With an average ridge line height of about 2000 feet — some peaks approaching 3000 to 4000 feet — these mountains are effective barriers to the prevailing northwesterly winds. The valley is 27 miles long, with the towns of Napa and Calistoga at its southern and northern ends, respectively. The Napa Valley is widest at its southern end, almost five miles wide; it narrows in the north to less than a mile wide at Calistoga. A minor pass, Knight's Valley, links the northern end of the valley to the Alexander Valley to the west.

During the day, the prevailing winds flows upvalley — from the southwest through south-southeast — about 53 percent of the time. A strong upvalley wind frequently develops during warm summer afternoons, drawing air in from the San Pablo Bay. The second most common winds — occurring roughly 26 percent of the time — flow downvalley from the north-northwest through the northeast. During the evening, especially in the winter, downvalley drainage often occurs.

Wind speeds are generally low, with almost 50 percent of the winds between zero and 4 mph. Only 5 percent of the winds are between 16 and 18 mph, representing strong summertime upvalley winds and winter storm winds.

Summer average maximum temperatures are in the low 80's at the southern end of the valley and in the low 90's at the northern end. Winter average maximum temperatures are in the high-50's and low-60's and minimum temperatures are in the high to mid 30's with the slightly cooler temperatures favoring the northern end. Sunshine is plentiful and annual precipitation averages range from 43 inches in the mountains to 24 inches at Napa.

The air pollution potential in the Napa Valley could be high — if there were sufficient sources of air contaminants nearby. Summer and fall prevailing winds can transport ozone precursors — northward from the Carquinez Strait Region — to where the Napa Valley narrows, effectively trapping and concentrating the pollutants when stable conditions are present. The local upslope and downslope flows created by the surrounding mountains may also recirculate pollutants already present, thereby adding to the total burden. Ozone buildup is a potential problem to sensitive crops such as wine grapes, as well as to human health.

The high frequency of light winds and stable conditions during the late fall and winter contribute to the buildup of particulate matter from automobiles, agricultural burning and woodburning in fireplaces and stoves. Carbon monoxide has not been a problem in recent years, but it too could increase with growth of population and tourist travel in the valley.

Northern Alameda and Western Contra Costa Counties

This climatological subregion stretches from Richmond to San Leandro. Its western boundary is defined by San Francisco Bay and its eastern boundary by the Oakland-Berkeley Hills. The Oakland-Berkeley Hills have a ridge line height of approximately 1500 feet — a significant barrier to air flow.

The most densely populated area of the subregion lies between the bay and the lower hills, in a narrow strip of land averaging about 4 miles in width. This subregion is home to an international airport, a large number of major industrial facilities, a large university, a major military facility currently being decommissioned and more than three quarters of a million people.

In this area, marine air traveling through the Golden Gate, as well as across San Francisco and through the San Bruno Gap, is a dominant weather factor. The Oakland-Berkeley Hills cause the westerly flow of air to spin off to the north and south of Oakland, which causes diminished wind speeds.

Temperatures in this subregion have a narrow range due to the proximity of the moderating marine air. Maximum temperatures in summer average in the upper-60's to low-70's, with minimums in the mid-50's. Winter highs are in the mid- to high-50's; winter lows are in the low- to mid-40's. Precipitation totals generally increase from south to north and from the lowlands to the Oakland-Berkeley Hills ridge line.

Data from meteorological monitoring stations indicate some significant variations among subareas of this subregion. For instance, Alameda Island, two miles southeast of the Bay Bridge, has a strong prevailing wind pattern from the west because of its closeness to the Golden Gate. The average speed for this sector is 9 mph. Maximum temperatures in summer average in the upper-60's, with minimum in the mid-50's. Winter highs are in the mid-50's and winter lows in the mid-40's. Sunshine is somewhat more scarce than at inland locations; and precipitation averages about 20 inches per year.

The Oakland Airport, 10 miles southeast of the Bay Bridge, records a wind regime very similar to that of Alameda. A bay breeze effect along the immediate shoreline, probably augmented by a wind flow over the low hills to the east, gives rise to a prevailing wind from the west. The second most frequent wind flows are from the southeast, particularly in winter; this may be due to the nearby Hayward Gap. Summer maximum temperatures are slightly higher, and winter minimum slightly lower than those of Alameda, as would be expected further away from the moderating effect of marine air. Maximum summer temperatures average near the 70's and minimums average in the low-50's. Sunshine is slightly more plentiful than at the coast, but less than inland.

Berkeley, built along the eastern edge of the San Francisco Bay ten miles due east of the Golden Gate, has maximum temperatures in summer which average in the 70's; winter highs are in the high-50's to low-60's. Annual precipitation averages 23 inches.

Richmond, the northernmost city of this zone, is ten miles northeast of the Golden Gate. At the Point San Pablo meteorological station, 4.5 miles west-northwest of downtown Richmond, the prevailing wind direction is from the south-southwest, and the average wind speed is 11 mph. Richmond's maximum summer temperatures average in the low-70's and minimums average in the mid-50's. In winter, maximums are in the high-50's to low-60's and minimums are in the low- to mid-40's. Annual precipitation totals 22 inches, on the average.

The air pollution potential is lowest for the areas of the subregion that are closest to the marine air (e.g. Berkeley, Alameda, Albany) due largely to good ventilation and less influx of pollutants from upwind sources. The occurrence of light winds in the evenings and early mornings occasionally causes elevated pollutant levels. The air pollution potential at the northern (Richmond) and southern (Oakland, San Leandro) subareas of this subregion is marginally higher than communities directly east of the Golden Gate, because of the lower frequency of strong winds.

This subregion contains heavy industrial air pollution sources, including refineries and chemical plants; some industries are quite close to residential areas. The subregion is also traversed by frequently congested major freeways. Traffic and congestion — and the motor vehicle emissions they generate — are increasing.

Peninsula

The peninsula region of the Bay Area extends from northwest of San Jose to the Golden Gate. The Santa Cruz Mountains run up the center of the peninsula, with elevations exceeding 2000 feet at the southern end, decreasing to 500 feet elevation in South San Francisco. On the west side of the mountains lie small coastal towns, such as Half Moon Bay and Pacifica. Because of the ocean upwelling and northwest winds, these coastal towns experience a high incidence of cool, foggy weather in the summer. On the eastern side of the mountain range lies the larger peninsula cities, such as San Mateo, Redwood City and Palo Alto. Cities in the southeastern

peninsula experience warmer temperatures and fewer foggy days because the marine layer is blocked by the 2000 foot ridge to the west. At the northern end of the peninsula lies San Francisco. Because most of San Francisco's topography is below 200 feet, the marine layer is able to flow easily across most of the city, making its climate cool and windy.

The blocking effect of the Santa Cruz Mountains is reflected by differences in summertime maximum temperatures in different parts of the peninsula.. For example, in Half Moon Bay and San Francisco the mean maximum daily summer temperatures are in the low-60's, while in Redwood City the mean maximum summer temperatures are in the low-80's. Daily mean maximum temperatures on the peninsula during the winter months are in the upper-50's.

Two important gaps in the Santa Cruz Mountains occur on the peninsula. The larger of the two is the San Bruno Gap, extending from Fort Funston on the ocean to the San Francisco Airport. Because the gap is oriented in the same northwest to southeast direction as the prevailing winds, and because the elevations along the gap are under 200 feet, marine air is easily able to penetrate into the bay.

The other gap in the Santa Cruz Mountains is the Crystal Springs Gap, along Highway 92 between Half Moon Bay and San Carlos. The low point is 900 feet, with elevations of 1500 feet north and south of the gap. As the sea breeze strengthens on summer afternoons, the gap permits maritime air to pass across the mountains, and its cooling effect is commonly seen from San Mateo to Redwood City.

Annual average wind speeds range from 5 to 10 mph throughout the peninsula, with higher wind speeds usually found along the coast. However, winds on the eastern side of the peninsula are often high in certain areas, such as near the San Bruno Gap and the Crystal Springs Gap.

The prevailing winds along the peninsula's coast, are westerly although individual sites can show significant differences. For example, Fort Funston in western San Francisco County shows a southwest wind pattern while Pillar Point in San Mateo County shows a northwest wind pattern. Sites on the east side of the mountains also show a westerly pattern, although wind patterns in this area are often influenced by local topographic features. A rise in elevation of a few hundred feet will induce flow around that feature instead of over it during stable atmospheric conditions. This can change the wind pattern by as much as 90 degrees over short distances. On mornings without a strong pressure gradient, areas on the east side of the peninsula often experience eastern flow in the surface layer, induced by upslope flow on the east-facing slopes and by the bay breeze. The bay breeze is rarely seen after noon because the stronger sea breeze begins to dominate the flow pattern.

Rainfall on the eastern side of the peninsula is somewhat lower than on the western side, with San Francisco and Redwood City both reporting annual averages of about 20 inches. On the coast, Half Moon Bay reports 25 inches per year. Areas in the Santa Cruz

Mountains show significantly higher rainfall levels — especially west of the ridge line — due to condensation induced by the lifting of the air flow as it passes over the mountains, close proximity to a moisture source, and fog drip.

Air pollution potential is highest along the southeastern portion of the peninsula. This is the subarea most protected from the high winds and fog of the marine layer. Pollutant transport from upwind sites is common.

Near the Silicon Valley, in the southeastern portion, emission densities are relatively high from motor vehicle traffic as well as stationary sources. Along the bay, further north, emission sources include congested traffic, an international airport, and industry. At the northern end of this subregion, in San Francisco, pollutant emissions are high, especially from motor vehicle congestion; localized pollutants, such as carbon monoxide, can build up in "urban canyons". However, winds are generally fast enough to carry the pollutants away before they can accumulate.

Santa Clara Valley

The Santa Clara Valley is oriented northwest-southeast and is bounded by the Santa Cruz Mountains to the west, the Diablo Range to the east, the San Francisco Bay to the north and the convergence of the Gabilan Range and the Diablo Range to the south. Temperatures are warm on summer days and cool on summer nights, and winter temperatures are fairly mild. At the northern end of the Santa Clara Valley, the San Jose Airport mean maximum temperatures range from the high-70's to the low-80's during the summer to the high-50's and low-60's during the winter, and mean minimum temperatures range from the high-50's in the summer to the low-40's in the winter. Further inland, where the moderating effect of the bay is not as strong, temperature extremes are greater. For example, in San Martin, located 27 miles south of the San Jose Airport, temperatures can be more than 10 degrees warmer on hot summer afternoons and more than 10 degrees cooler on cold winter nights. Rainfall is modest, ranging from 13 inches in the lowlands to 20 inches in the hills.

The wind patterns in the valley are greatly influenced by the terrain, resulting in a prevailing flow that roughly parallels the valley's northwest-southeast axis. A north-northwesterly sea breeze extends up the valley during the afternoon and early evening and a light south-southeasterly drainage flow occurs during the late evening and early morning. In the summer the southern end of the valley, between Gilroy and Morgan Hill, sometimes becomes a "convergence zone" — when air flowing from the Monterey Bay through the Pajaro Gap gets channeled northward into the southern end of the Santa Clara Valley and meets with the prevailing north-northwesterly.

Wind speeds are greatest in the spring and summer and weakest in the fall and winter. Nighttime and early morning hours frequently have calm winds in all seasons, while summer afternoons and evenings are quite breezy. Strong winds are rare, associated mostly with the occasional winter storm.

The air pollution potential of the Santa Clara Valley is high. In addition to the many local sources of pollution, photochemical precursors from San Francisco, San Mateo and Alameda Counties are carried by prevailing winds to the Santa Clara Valley, making it a major ozone receptor. Geographically, the valley tends to channel pollutants to the southeast with its northwest/southeast orientation. In addition, on summer days with low level inversions, ozone can be recirculated by southerly drainage flow in the late evening and early morning and by the prevailing northwesterlies in the afternoon. A similar recirculation pattern occurs in the winter affecting levels of carbon monoxide and particulate matter. This "sloshing" of the air up and down the valley increases the impact of the pollutants significantly (see section on Wind Circulation).

Pollution sources are plentiful and complex in this subregion. The Santa Clara Valley has a high concentration of industry at the northern end, in the Silicon Valley; some of these industries are sources of air toxics as well as criteria pollutants. In addition, Santa Clara Valley's large population and many work-site destinations generate the highest mobile source emissions of any subregion in the Bay Area. The subregion is a major source — as well as recipient — of ozone and its precursors. Carbon monoxide and particulate matter can also become concentrated.

Sonoma Valley

The Sonoma Valley lies to the west of the Napa Valley. It is separated from the Napa Valley by the Mayacamas Mountains and from the Cotati and Petaluma Valleys by the Sonoma Mountains, which are not as high nor as extensive as the Mayacamas. The Sonoma Valley is long and narrow, being no more than 5 miles wide at its southern end, and quickly shrinking to 2 miles and then to less than a mile wide further north.

The climate is similar to that of the Napa Valley, with the same basic wind characteristics; strongest upvalley winds in the afternoon during the summer and strongest downvalley winds during clear, calm winter nights. Prevailing winds follow the longitudinal axis of the valley, northwest/southeast, while some upslope flow during the day and downslope flow during the night may be observed near the base of the mountains. In the town of Sonoma, summer average maximum temperatures are usually in the high-80's, and summer minimums are around 50 degrees. Winter maximums are in the high-50's to the mid-60's, with minimums ranging from the mid-30's to low-40's. Sunshine is plentiful and annual precipitation averages 29 inches.

As in the Napa Valley, the air pollution potential of the Sonoma Valley could be high — if there were significant sources of pollution nearby. Prevailing winds can transport locally and non-locally generated ozone precursors northward into the narrow valley, which often traps and concentrates the pollutants under stable conditions. The local upslope and downslope flows set up by the surrounding mountains may also recirculate pollutants.

However sources of pollution close-in are few. With the exception of some processing of agricultural goods,

such as wine and cheese manufacturing, there is little industry in this valley. The Sonoma Valley is sufficiently distant — and usually upwind — from the emissions of the heavy industry of the Carquinez Strait Region. Increases in motor vehicle emissions and woodsmoke emissions from stoves and fireplaces may increase pollution as the valley grows in population — and as a tourist attraction.

Southwestern Alameda County

This subregion encompasses the southeast side of San Francisco Bay, from south of Hwy. 580/Dublin Canyon to north of Milpitas. The subregion is bordered on the east by the East Bay hills and on the west by the bay; most of the area is flat. The major cities are San Lorenzo, Hayward, Union City, Newark, and Fremont.

Situated between the eastern and western portions of the Coast Range, this subregion is indirectly affected by marine air flow. Marine air entering through the Golden Gate is blocked by the East Bay hills, forcing the air to diverge into northerly and southerly paths. The southern flow is directed southeasterly down the bay, parallel to the hills, where eventually it passes over southwestern Alameda County. These sea breezes are strongest in the afternoon. The further from the ocean the marine air travels, however, the more it is modified. Thus, although the climate in this region is affected by sea breezes, it is affected less so than the regions closer to the Golden Gate.

In addition to these sea breezes, the climate of southwestern Alameda County is also modified by its close proximity to San Francisco Bay. Evaporation from the bay cools the air that comes in contact with it during warm weather, while during cold weather the bay warms the air. The normal northwest wind pattern carries this air onshore. During periods of flat pressure gradients, the bay can generate its own circulation system. This bay breeze, similar to the sea breeze, pushes cool air onshore during the daytime and draws air from the land offshore at night.

Winds are predominantly out of the northwest during the summer months. In the winter, however, winds are equally likely to be from the east. Cold air over land areas creates high pressure to the east, which forces air toward the west. Easterly-southeasterly surface flow into southern Alameda County passes through three major gaps: Hayward/Dublin Canyon, Niles Canyon, and Mission Pass. Areas north of the gaps experience winds from the southeast, while areas south of the gaps experience winds from the northeast. Wind speeds are moderate in this subregion, with annual average wind speeds close to the bay at about 7 mph, while further inland they average 6 mph.

Air temperatures are moderated by the subregion's proximity to the bay and to the sea breeze. Temperatures are slightly cooler in the winter and slightly warmer in the summer than East Bay cities to the north. Average maximum winter temperatures are in the high-50's to low-60's. During the summer months, average maximum temperatures are in the mid-60's. Average minimum

temperatures are in the low 40's in winter and mid-50's in the summer.

Rainfall in the region is lower than other East Bay cities to the north. Areas near the bay have lower rainfall amounts because of the rain shadow effect of the Santa Cruz Mountains. The annual rainfall in Newark, for instance, is 14 inches. Areas closer to the hills have higher rainfall amounts because they are further from the Santa Cruz Mountains and because of orographic effects (i.e., air is forced to ascend the mountains and then cools and condenses, leading to increased rain).

Pollution potential is relatively high in this subregion during the summer and fall. When high pressure dominates, low mixing depths and bay and ocean wind patterns can concentrate and carry pollutants from other cities to this area, adding to the locally emitted pollutant mix. The polluted air is then pushed up against the East Bay hills. In the wintertime, the air pollution potential in southwestern Alameda county is moderate.

Air pollution sources include light and heavy industry — including automobile and truck manufacturing, assembly, and painting. Increasing motor vehicle traffic and congestion in the subregion may increase Southwest Alameda County pollution as well as that of its neighboring subregions.

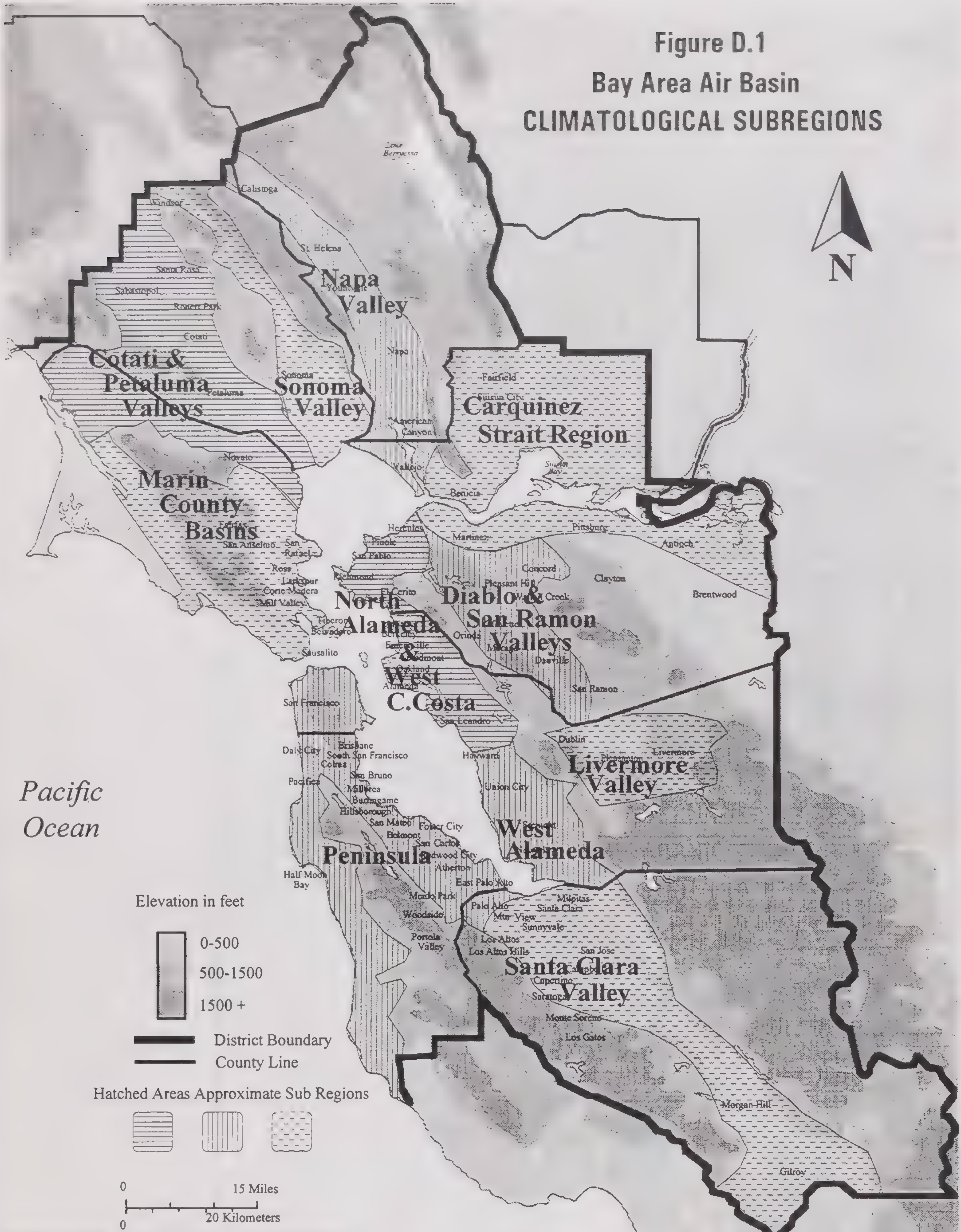
County - Subregional References

Some climatological subregions, as described above, overlap county boundaries; obversely, some counties contain parts of one or more subregions within their borders. Cities and counties which are close to the boundary between subregions — e.g. Vallejo, Pleasanton, Palo Alto, and most counties — may find it useful to explore the characteristics of the neighboring subregions. Table D.1 matches counties to the subregions that are partially or entirely contained within them.

Table D.1 BAY AREA COUNTIES AND CLIMATOLOGICAL SUBREGIONS

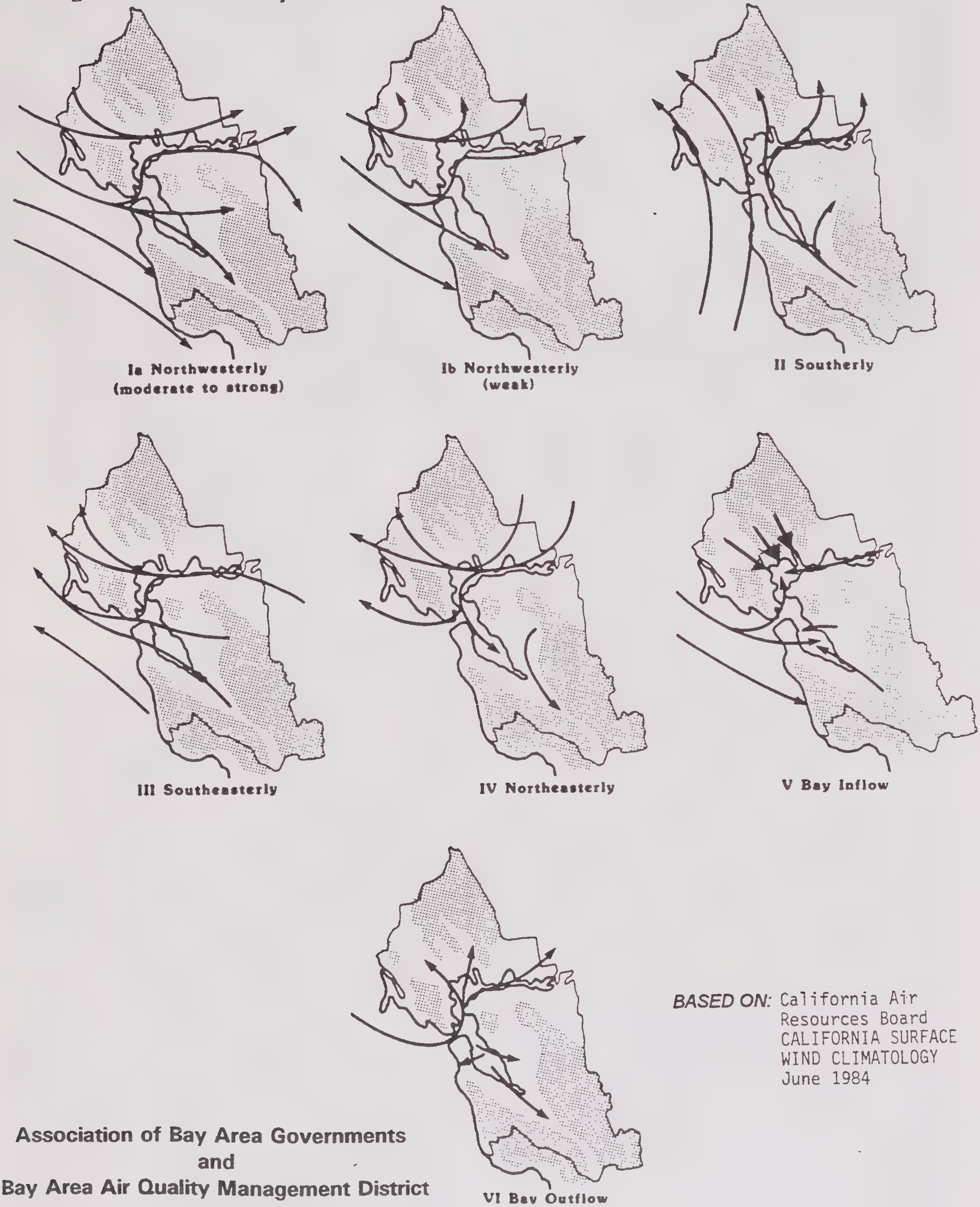
COUNTIES	CLIMATOLOGICAL SUBREGIONS
ALAMEDA	Diablo and San Ramon Valleys (southern part) Livermore Valley Northern Alameda and Western Contra Costa Counties (southern part) Southwestern Alameda County
CONTRA COSTA	Carquinez Strait Region (southern part) Diablo and San Ramon Valleys (northern part) Northern Alameda and Western Contra Costa County (northern part)
MARIN	Marin County Basins
NAPA	Napa Valley
SAN FRANCISCO	Peninsula (northern part)
SAN MATEO	Peninsula (central part)
SANTA CLARA	Santa Clara Valley Peninsula (southern end)
SOLANO	Carquinez Strait Region (northern part)
SONOMA	Sonoma Valley Cotati and Petaluma Valley

Figure D.1
Bay Area Air Basin
CLIMATOLOGICAL SUBREGIONS



ASSOCIATION OF BAY AREA GOVERNEMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

Figure D.2 Bay Area Air Basin REGIONAL WIND PATTERNS



BASED ON: California Air Resources Board CALIFORNIA SURFACE WIND CLIMATOLOGY June 1984

**Association of Bay Area Governments
and
Bay Area Air Quality Management District**

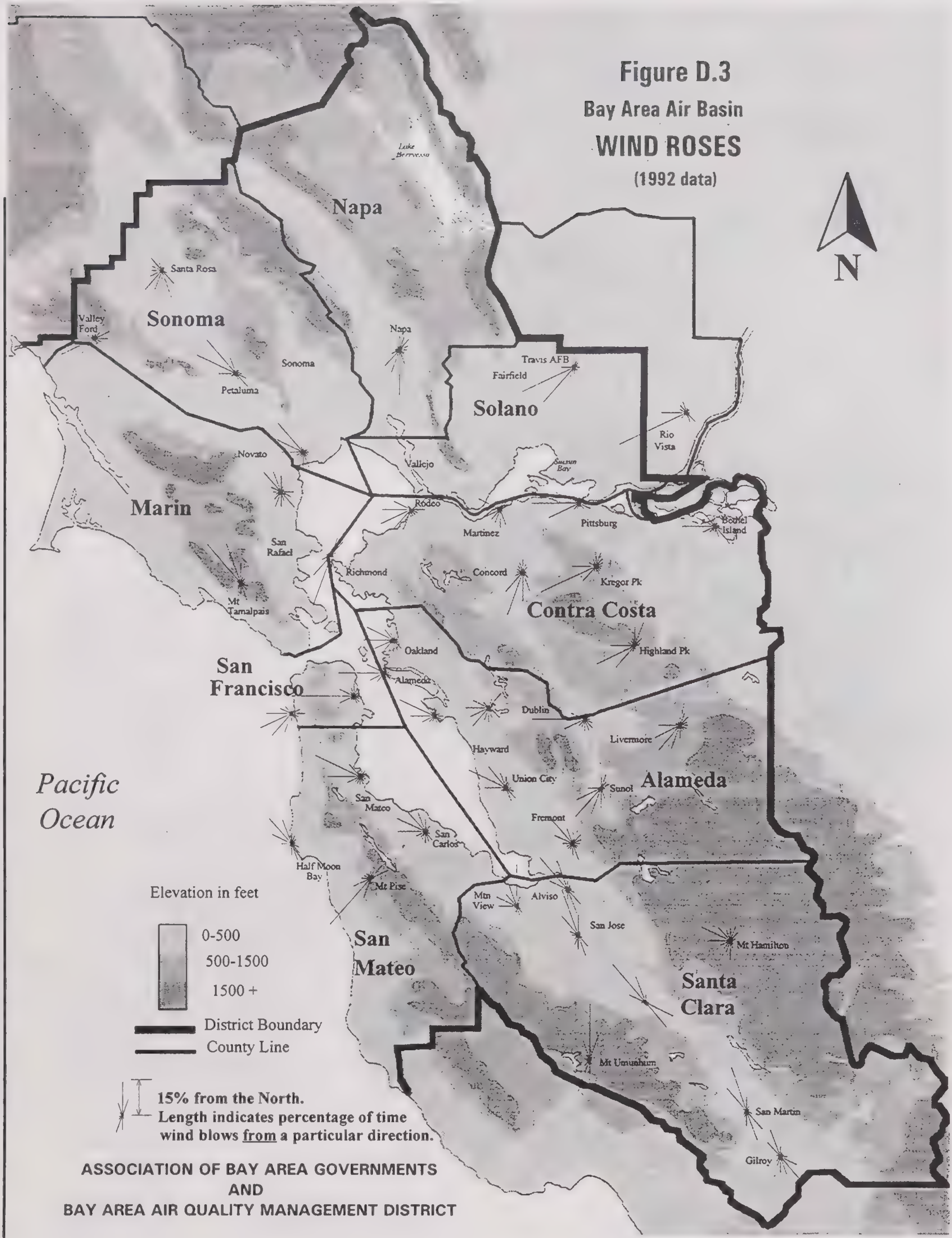


Figure D.3
Bay Area Air Basin
WIND ROSES
(1992 data)
N
Napa
Sonoma
Solano
Marin
San Francisco
Contra Costa
Alameda
San Mateo
Santa Clara
Pacific Ocean
Lake Berryessa
Santa Rosa
Valley Ford
Petaluma
Sonoma
Napa
Travis AFB
Fairfield
Rio Vista
Novato
Vallejo
Suisun Bay
Rodeo
Martinez
Pittsburg
Bethel Island
San Rafael
Richmond
Concord
Kregor Pk
Mt Tamalpais
Highland Pk
Oakland
Alameda
Dublin
Livermore
Hayward
Union City
Sunol
Fremont
San Mateo
San Carlos
Half Moon Bay
Mt Pise
Mtn View
Alviso
San Jose
Mt Hamilton
Mt Umunhum
San Martin
Gilroy
Elevation in feet
0-500
500-1500
1500 +
District Boundary
County Line
15% from the North.
Length indicates percentage of time wind blows from a particular direction.
ASSOCIATION OF BAY AREA GOVERNMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT

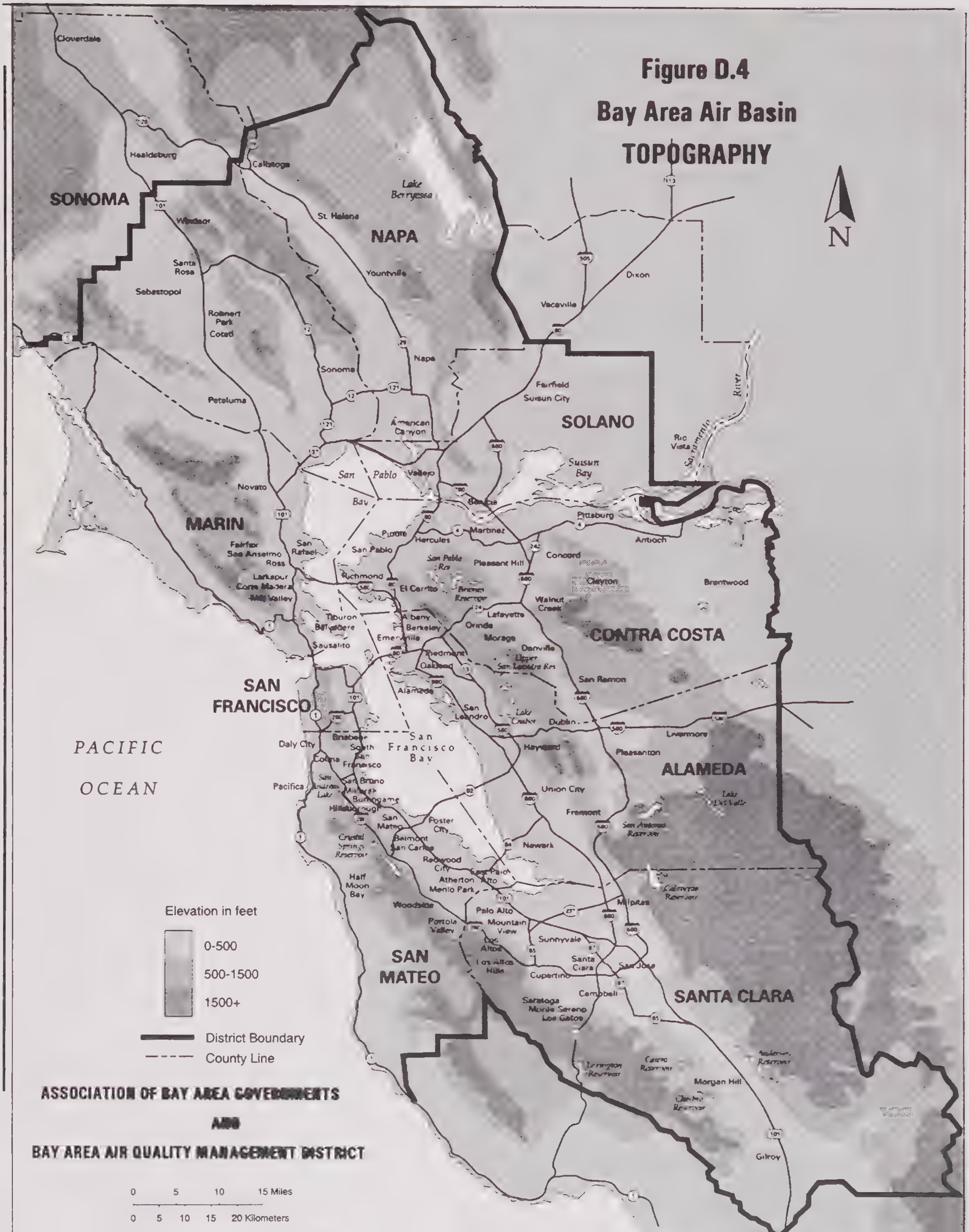


Figure D.4
Bay Area Air Basin
TOPOGRAPHY
N
SONOMA
NAPA
SOLANO
MARIN
CONTRA COSTA
SAN FRANCISCO
ALAMEDA
SAN MATEO
SANTA CLARA
PACIFIC OCEAN
San Pablo Bay
San Francisco Bay
Suisun Bay
Lake Berryessa
Cloverdale
Healdsburg
Calistoga
Windsor
St Helena
Santa Rosa
Sebastopol
Yountville
Rohnert Park
Cotati
Sonoma
Napa
Petaluma
American Canyon
Vacaville
Dixon
Fairfield
Suisun City
Rio Vista
Novato
Vallejo
Benicia
Martinez
Pittsburg
Antioch
Brentwood
Concord
Clayton
Pleasant Hill
Walnut Creek
Hercules
Pinole
San Pablo
Richmond
El Cerrito
San Rafael
Fairfax
San Anselmo
Ross
Larkspur
Corte Madera
Mill Valley
Tiburon
Belvedere
Sausalito
Albany
Berkeley
Emeryville
Orinda
Lafayette
Moraga
Danville
Piedmont
Oakland
Alameda
San Ramon
San Leandro
Dublin
Livermore
Pleasanton
Hayward
Union City
Fremont
Newark
Daly City
Brisbane
South San Francisco
Colma
Pacifica
San Bruno
Millbrae
Burlingame
Hillsborough
San Mateo
Foster City
Belmont
San Carlos
Redwood City
East Palo Alto
Atherton
Menlo Park
Half Moon Bay
Woodside
Portola Valley
Palo Alto
Mountain View
Los Altos
Los Altos Hills
Sunnyvale
Santa Clara
Milpitas
San Jose
Cupertino
Campbell
Saratoga
Monte Sereno
Los Gatos
Morgan Hill
Gilroy
Sacramento River
Elevation in feet
0-500
500-1500
1500+
District Boundary
County Line
ASSOCIATION OF BAY AREA GOVERNMENTS
AND
BAY AREA AIR QUALITY MANAGEMENT DISTRICT
0 5 10 15 Miles
0 5 10 15 20 Kilometers

APPENDIX E: LOCAL PLANNING STRATEGIES

Appendix E supplements the information presented in the Checklist in the Guidebook (pages 14 through 19). This appendix presents an extended range of strategies and specific measures for addressing air quality at the local level. Local planners can refer to these lists and descriptions when reviewing policy and program options appropriate for their specific community. The first section contains the broad principles set forth at the "Ahwahnee Conference" of city, county and State officials and other community leaders (Local Government Commission and Calthorpe, 1991). The second section "Selected Measures Appropriate to Differing Community Conditions," including Table E.1, helps sort out the most appropriate measures for communities and counties with specific types of local characteristics. The last section of this appendix, "Extended List of Measures for Addressing Air Quality", categorizes a large number of actions applicable to local government.

City and county planners in the Bay Area should find, within these lists, valuable concepts for formulating plans, policies and programs that are beneficial to air quality. Yet, the lists are not intended to be a comprehensive inventory of all options available to local governments; they should serve as a useful starting point to spur the problem-solving creativity of local planners — and/or their consultants. (For additional detail on policies and programs which might be applicable or translatable to local conditions, refer to publications listed in the Bibliography found at the end of this set of appendices.)

The Ahwahnee Principles

The principles set forth at the Ahwahnee conference are listed below. Many of the Ahwahnee principles are designed to achieve community and regional goals other than healthful air quality; yet all are consistent with good air quality planning practices.

Preamble:

Existing patterns of urban and suburban development seriously impair our quality of life. The symptoms are: more congestion and air pollution resulting from our increased dependence on automobiles, the loss of precious open space, the need for costly improvements to roads and public services, the inequitable distribution of economic resources, and the loss of a sense of community. By drawing upon the best from the past and the present, we can plan communities that will more successfully serve the needs of those who live and work within them. Such planning should adhere to certain fundamental principles.

Community Principles

1. All planning should be in the form of complete and

integrated communities containing housing, shops, work places, schools, parks and civic facilities essential to the daily life of the residents.

2. Community size should be designed so that housing, jobs, daily needs and other activities are within easy walking distance of each other.

3. As many activities as possible should be located within easy walking distance of transit stops.

4. A community should contain a diversity of housing types to enable citizens from a wide range of economic levels and age groups to live within its boundaries.

5. Businesses within the community should provide a range of job types for the community's residents.

6. The location and character of the community should be consistent with a larger transit network.

7. The community should have a center focus that combines commercial, civic, cultural and recreational uses.

8. The community should contain an ample supply of specialized open space in the form of squares, greens and parks whose frequent use is encouraged through placement and design.

9. Public spaces should be designed to encourage the attention and presence of people at all hours of the day and night.

10. Each community or cluster of communities should have a well defined edge, such as agricultural greenbelts or wildlife corridors, permanently protected from development.

11. Streets, pedestrian paths and bike paths should contribute to a system of fully-connected and interesting routes to all destinations. Their design should encourage pedestrian and bicycle use by being small and spatially defined by buildings, trees and lighting, and by discouraging high speed traffic.

12. Wherever possible, the natural terrain, drainage, and vegetation of the community should be preserved with superior examples contained within parks or greenbelts.

13. The community design should help conserve resources and minimize waste.

14. Communities should provide for the efficient use of water through the use of natural drainage, drought tolerant landscaping and recycling.

15. The street orientation, the placement of buildings and the use of shading should contribute to the energy efficiency of the community.

Regional Principles

1. The regional land use planning structure should be integrated within a larger transportation network built around transit rather than freeways.

2. Regions should be bounded by and provide a continuous system of greenbelt/wildlife corridors to

be determined by natural conditions.

3. Regional institutions and services (government, stadiums, museums, etc.) should be located in the urban core.

4. Materials and methods of construction should be specific to the region, exhibiting continuity of history and culture and compatibility with the climate to encourage the development of local character and community identity.

Implementation Strategy

1. The general plan should be updated to incorporate the above principles.

2. Rather than allowing developer-initiated, piecemeal development, local governments should take charge of the planning process. General plans should designate where new growth, infill or redevelopment will be allowed to occur.

3. Prior to any development, a specific plan should be prepared based on the planning principles. With the adoption of specific plans, complying projects could proceed with minimal delay.

4. Plans should be developed through an open process and participants in the process should be provided visual models of all planning proposals.

Selected Measures Appropriate To Differing Community Conditions

This section illustrates some of the variables to be considered when developing air quality management strategies appropriate to local conditions. Table E.1 presents a matrix that matches the appropriateness of any measure to an existing condition (development and transportation status). A plus sign (+) indicates that the fit or match is usually appropriate. A minus sign (-) indicates a mismatch, in the usual situation. An S denotes that study of the individual situation is usually warranted; the fit depends on sometimes subtle relationships of long-term outcomes, need, feasibility, cost effectiveness and/or environmental and socioeconomic impacts.

Under the column "community type" are the sub-columns: central city, suburb, edge city (former residential suburbs which have added significant amounts of commercial and/or industrial development and service facilities), and rural town. An example of the differences in applicability of measures might include the following: an emphasis on mixed uses, as a land use measure, will usually be appropriate in all community types except in some areas that are planned to remain rural.

In terms of other community conditions, high density areas present different opportunities and problems vis-a-vis air quality than do more sparsely settled areas, and different planning solutions are appropriate. An existing area which is already built-out will not have the same opportunity to introduce large scale air-quality-sensitive land use measures as an area for which development is

still in the planning stages — unless the built-out area is to be redeveloped. Obviously residential areas, commercial areas, and industrial areas will differ in opportunities and problems — including the appropriateness of providing a buffer zone. The existence of adequate transit service — as in San Francisco — will allow measures that are not available or not meaningful in areas with only minimal transit — as in most of Napa County. Finally, the variables of traffic congestion, as opposed to areas with free-flow traffic, will determine which measures are needed and/or feasible to improve air quality.

An example of the need for site specific studies is the traditional approach to improving or expanding roadways to reduce traffic congestion. A site specific study would explore whether short-term reduction of congestion (and improvement of air quality) would be counterbalanced in the long-term by inducement of more traffic (and increased emissions) on higher capacity roads.

Table E.1 SELECTED MEASURES APPROPRIATE TO DIFFERING COMMUNITY CONDITIONS

MEASURE	IMPLEMENTATION TOOLS	Development and Transportation Status of Local Area														
		COMMUNITY TYPE				DENSITY		BUILD-OUT		LAND USE			TRANSIT		TRAFFIC	
		Central City	Suburb	Edge City	Rural Town	High	Low	Existing	Potential	Residential	Commercial	Industrial	Extensive	Minimum	Congested	Free Flow
LAND USE																
Compact development and infill	Zoning ordinance	+	+	+	S	S	+	S	+	+	+	+	+	S	+	S
Mixed uses	Zoning ordinance	+	+	+	S	+	+	S	+	S	+	S	+	+	+	S
Transit-Oriented Development (TOD)--new development or redevelopment	Zoning, subdivision ordinance, PUD ord., &/or redevelopment	+	+	+	S	+	+	S	+	+	+	S	+	+	+	+
HOUSING																
Increased density near transit stations	Zoning, redevelopment or specific plan	+	+	+	S	+	S	S	+	+	+	+	+	-	+	S

LEGEND:

+ = Usually Appropriate
- = Usually Not Appropriate
S = Requires Site-Specific Study re Feasibility and long-term Environmental & Socioeconomic Impacts.

Table E.1 (Continued)

MEASURE	IMPLEMENTATION TOOLS	Development and Transportation Status of Local Area														
		COMMUNITY TYPE				DENSITY		BUILD-OUT		LAND USE			TRANSIT		TRAFFIC	
		Central City	Suburb	Edge City	Rural Town	High	Low	Existing	Potential	Residential	Commercial	Industrial	Extensive	Minimum	Congested	Free Flow
TRANSPORTATION																
Improve/expand transit	CIP, RTP, local transit plan, budget	+	+	+	S	+	S	+	+	S	+	+	+	S	+	S
Parking—limit maximum spaces &/or pricing strategy	Regulations, re time-limits and minimum parking prices	+	S	+	S	+	S	+	+	S	+	+	+	S	+	S
TDM, including TROs delegated by Air District	TDM ordinance	+	+	+	S	+	S	+	+	S	+	+	+	S	+	+
Roadway improvements	Local CMP	S	S	S	S	S	S	S	S	S	S	+	S	+	S	-
Establish bike & pedestrian improvements and links between areas	CIP, local transportation plans	+	+	+	+	+	+	S	+	+	+	S	+	+	+	S
Clean fuel motor vehicle fleets — public and private	City/county equipment; regulations re private fleets.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

LEGEND:

+ = Usually Appropriate
- = Usually Not Appropriate
S = Requires Site-Specific Study re Feasibility and long-term Environmental & Socioeconomic Impacts.

Table E.I (Continued)

MEASURE	IMPLEMENTATION TOOLS	Development and Transportation Status of Local Area														
		COMMUNITY TYPE				DENSITY		BUILD-OUT		LAND USE			TRANSIT		TRAFFIC	
		Central City	Suburb	Edge City	Rural Town	High	Low	Existing	Potential	Residential	Commercial	Industrial	Extensive	Minimum	Congested	Free Flow
OPEN SPACE																
Buffer zone separating incompatible uses	Capital Improvement Prog. &/or ordinance for private land	S	S	+	+	-	+	-	+	S	S	+				
Urban growth boundary	Zoning ordinance	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
OTHER																
Dust control/ grading rules	Ordinance(s)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Energy conservation program	Ordinance, public education	+	+	+	+	+	+	S	+	+	+	+	+	+	+	+

LEGEND:

+ = Usually Appropriate
- = Usually Not Appropriate
S = Requires Site-Specific Study re Feasibility and long-term Environmental & Socioeconomic Impacts.

Extended List Of Measures for Addressing Air Quality

The following list contains specific measures which are — or can be — controlled, or at least influenced, by local government planning actions. (The list overlaps the Checklist of the Guidebook text and Appendix F). A wide array of categories and specific measures are provided; many have already proven their utility in various cities and counties across the United States. Planners in every city and county in the Bay Area should find at least some items that are applicable, and feasible, for their individual situations.

Land Use Strategies

Transit-Oriented Development

- Increase allowable land use densities and/r establish minimum densities of residential and employment uses near existing or planned transit stations and bus corridors.
- Locate highest land use densities within 1/4 mile of transit stations.
- Establish compact, pedestrian-oriented community center areas of mixed use development — including residential, employment and services — near transit stations, transfer centers and major bus corridors.
- Develop specific plans for areas near transit stations where higher density, mixed use development is desired.
- Encourage compact, pedestrian-oriented mix of residential, commercial and employment land uses along major bus corridors.
- Locate highest density office uses within 1/4 mile radius of transit stations or transfer centers to promote transit use and limit auto impacts of higher density development.
- Limit commercial and office development in areas not served by transit.
- Direct auto-dependent commercial uses, such as auto/tire sales, auto repair, etc. to areas not served by transit.
- Increase allowable residential densities near activity centers such as civic centers, recreation areas and city centers.
- Concentrate highest residential densities within 1/4 mile of transit stations, and decrease densities gradually to provide transition between high and low or moderate densities.
- Work with transit providers to seek opportunities for joint development projects near transit stations.

Infill Development

- Encourage higher density, mixed use development on undeveloped or underdeveloped land in or near city centers and major suburban activity centers, particularly in areas served by public transit.
- Increase densities and encourage mixed use in planned and redeveloping urban, suburban and edge city activity centers.
- Maintain an inventory of undeveloped and under-developed parcels in the community and identify those parcels appropriate for higher density, mixed use development.
- Prepare specific plans for areas where infill development is desired.
- Streamline the project approval and environmental review processes for infill development projects compatible with neighboring land uses.
- Encourage the development of "in-law" or second residential units in appropriate locations.

Mixed Use Development

- Encourage mixed use development projects, especially near transit stations and urban and suburban centers.
- Require large new office/commercial developments to include housing or locate adjacent to existing or planned housing, when land uses are compatible.
- Require new and expanding office development to include commercial uses such as restaurants, ATMs, dry cleaners, post offices, etc. to reduce mid-day trips.
- Require ground-level retail at new office and multi-family residential developments.
- Facilitate the conversion of suitable underutilized industrial or commercial areas to residential or live/work uses, provided that surrounding uses do not pose health or nuisance threat.
- Encourage neighborhood retail and service uses in, or within walking distance of, residential areas.
- Integrate housing into existing and planned commercial developments by encouraging residential units alongside or above shops and offices.
- Encourage neighborhood work centers within residential areas.
- Encourage home occupations and home-based work.

Site Design to Support Transit, Pedestrians and Bicycles

- Require new office and retail development to locate buildings and building entrances near sidewalks, transit stops and other public areas, with parking in the rear.

- Require new office and retail development to provide direct, convenient pedestrian access to transit stops and public areas.

- Require new office and retail development to provide bus shelters and bus pullouts or bus bulbs near building entrances.

- Provide facilities such as shelters, benches, landscaping, and lighting at transit stops to protect riders from weather, improve safety, and otherwise enhance the attractiveness of transit.

- Require residential developers to provide or contribute to conveniently located park and ride facilities and/or shuttles to major transit facilities.

- Adopt design guidelines that promote an attractive pedestrian environment, including features such as sidewalks, street trees and landscaping, benches, and narrower street widths.

- Consider transit stops to be important destinations and important elements of projects' overall design.

Jobs/Housing Balance

- Cooperate with neighboring jurisdictions to balance jobs and housing in future development at the subregional level to improve housing availability, reduce traffic congestion, reduce long-distance commuting, and enhance auto alternatives such as walking, bicycling and transit.

- Manage the growth of employment generating land uses at a pace to maintain both a positive fiscal condition and a jobs/housing balance.

- Promote the development of a mix of housing types and costs to serve the need anticipated from employment projections by type and expected wage of employee.

- Expand employment opportunities for local residents, particularly the unemployed and economically disadvantaged.

- Establish job training and retraining programs that will impart skills necessary for the local labor market.

- Establish incentives for employers to hire local residents.

- Establish a citywide employment network to encourage new and existing businesses to recruit residents for local employment opportunities.

- Require developers to offer right-of-first-refusal on new housing units to employees of local businesses.

- Require an analysis of the impact on the local and subregional jobs/housing balance for all significantly sized residential and employment generating development proposals.

- For large mixed use projects, require that project phasing assures that residential and employment-generating land uses are built concurrently.

Sensitive Receptors

- Locate new air pollution point sources such as manufacturing and extracting facilities at appropriate distances away from residential areas and facilities that serve sensitive receptors.

- Provide a buffer zone, within which residential development is prohibited, around industry and other uses that may emit odors or dust.

- Include buffer zones within new residential and sensitive receptor site plans to separate those uses from freeways, arterials, point sources and hazardous material locations.

Housing Strategies

Housing Supply

- Designate land near transit stations and bus corridors for multi-family housing and neighborhood serving uses.

- Promote the provision of a range of residential unit sizes, types, lot designs and price levels in new developments.

- Increase maximum allowable densities and require residential projects within high density residential designations to achieve an appropriate minimum density.

- Encourage alternate forms of housing that increase overall density, such as attached units, "in-law" units, multi-family units, co-housing and clustered single family units.

- Designate vacant commercially zoned sites for residential use.

- Encourage the reuse of existing commercial or, where appropriate, industrial buildings for residential or live-work space.

- Encourage the development of special housing facilities, such as facilities for the elderly, mentally disabled or neglected children, in residential and mixed-use zones near transit and other services.

Housing Affordability

- Attempt to meet regional fair-share housing objectives for all income categories to minimize in-commuting

- Develop programs designed to provide housing for very low-, low- and moderate-income households.

- Encourage the construction and preservation of second dwelling units in single-family residential neighborhoods.

- Promote the preservation of existing affordable housing located near transit.

- Encourage the use of new manufactured homes, subject to appropriate design guidelines.

Transportation Strategies

Circulation Network

- Require new office/commercial and residential developments to incorporate a safe, comprehensive network of bicycle routes/paths in circulation plans.

- Require new residential development to accommodate alternate modes of transportation by providing facilities such as sidewalks, transit-compatible streets and circulation patterns, and bicycle facilities.

- Design residential streets with direct pedestrian and bicycle routes to nearby transit stations and stops, commercial areas, schools, and other activity centers.

- Discourage cul-de-sacs in new residential subdivisions and, if cul-de-sacs are included, require public easements for pedestrian and bicycle access.

- Prohibit walls around new residential subdivisions which limit pedestrian and bicycle access.

- Allow or require reduced street widths and reduced curb radii in residential development, except where significant levels of transit service are anticipated.

- Design arterial streets to include transit amenities such as sidewalks and curbs, bus bulbs or pull-outs, and bus stops at major boarding points.

- Identify streets appropriate for, and implement, "traffic calming" strategies such as narrower street widths, speed humps, expanded sidewalks, planters, etc.

Parking

- Establish maximum parking limits for commercial and employment-generating land uses.

- Reduce, where appropriate, existing parking requirements for commercial and employment-generating land uses, particularly in areas served by transit.

- Offer reductions in required parking to office and retail developers as an incentive to implement comprehensive trip reduction measures.

- Set an overall cap on the total amount of parking in areas with high employment concentrations.

- Encourage major employers to provide "parking cash-out" programs to employees.

- Require preferential parking for carpool and van-pool vehicles.

- Require secure, conveniently located bicycle parking at commercial and employment-generating land uses.

- Encourage shared use parking facilities.

Bicycle and Pedestrian Measures

- Prepare a bicycle circulation plan.

- Improve safety and convenience for bicyclists through roadway improvements such as widening shoulders, re-striping lanes and installing detection loops at intersections.

- Expand Class I bike paths and Class II bike lanes.

- Work with local transit provider(s) to expand access for bicycles on transit vehicles, and to increase the number of storage lockers and racks at transit stations.

- Encourage the provision of bicycle lockers and racks at park and ride lots.

- Require the provision of bicycle storage facilities and showers/changing rooms at large new or modified developments.

- Require new developments to provide safe, convenient and direct pedestrian pathways within the project, and between the project and nearby land uses, such as residences, stores, worksites, schools and/or recreational facilities.

- Provide direct, convenient and safe pedestrian access between transit stations and neighboring development.

- Provide pedestrian signals at intersections on heavily traveled roadways.

- Provide or require adequate lighting for sidewalks, bus stops, transit stations, bicycle parking areas and vehicle parking lots to enhance pedestrian safety.

Transit

- Provide bus stop bulbs or pull outs along major bus corridors.

- Require large developments to provide shelters, benches, landscaping and other amenities at bus stops serving the project.

- Enhance transit opportunities by working with local transit provider(s) to identify appropriate routes for reducing headways, extending service, improving transfers, and coordinating project design and services to new development.

- Establish transit information centers in downtown areas, major transit transfer stations, community centers and/or other activity centers to provide route information, schedules and passes.

- Cooperate with neighboring jurisdictions, transit providers and/or Caltrans to provide park and ride lots at appropriate locations.

- Work with transit providers to implement signal preemption for transit vehicles in appropriate locations.

- Work with school districts to implement school bus programs.

Conservation and Open Space Strategies

Urban Growth Boundaries

- Establish and enforce urban growth boundaries to direct new development contiguous to already developed areas and protect agricultural, recreational and environmentally sensitive lands.

- Designate an adequate amount, range and intensity of land uses within urban growth boundaries to meet anticipated demand.

- Allow only open space, park, recreational, agricultural and other low intensity uses outside urban growth boundaries.

- Encourage development near urban growth boundaries that is compatible with activities outside the boundaries.

- Seek annexations only for lands within the urban growth boundary and which provide for a contiguous development pattern.

Infrastructure

- Allow new development only in areas where infrastructure capacity is available or is planned and funded, including, but not limited to, road, transit, water, sewage treatment and solid waste disposal.

- Discourage "leapfrog" development by programming the extension of water and sewer lines only to areas contiguous with existing development.

- Pursue investments in major public facilities and urban amenities that support the further development of urban centers.

- Phase and limit extension of urban services within the urban growth boundaries.

Implementation Programs

Energy Conservation

- Require energy conservation features in all public and private development.
- Develop design guidelines to increase energy efficiency of new development.
- Encourage developers to orient structures to maximize solar heating and cooling.
- Perform an energy audit on all public buildings, and encourage energy audits on all private structures, in order to identify current energy use and potential conservation measures.
- Require energy efficient, low polluting fireplace inserts and/or woodstoves in all new residential development.
- Encourage the use of solar water and pool heaters.
- Require energy efficient lighting in new development and encourage retrofitting of existing structures with energy efficient lighting.
- Require new residential development to provide outdoor electrical outlets for electric lawn and garden equipment.

Tree Planting Programs

- Plant street trees and landscaping, in public projects, areas and rights-of-way, and require street trees and landscaping in new private development (Smith & Dochinger, 1976).
- Choose and site trees to cool urban heat islands — thus slowing photochemical ozone-generating reactions, reducing evaporation of fuels and solvents, and reducing energy demand for cooling buildings. Trees will also filter out particulates, absorb carbon, replenish oxygen in the ambient air and, in some cases, neutralize ozone (see: U.S. Environmental Protection Agency, 1976; Akbari et al, 1987, American Planning Association, 1992).
- Select species of trees which emit the least amounts of reactive organics (Winer, 1983; Chameides et al, 1988; Benjamin et al., 1994).

Zoning Ordinance

- Amend zoning ordinance to encourage transit oriented development by allowing mixed land uses and increasing allowable densities or setting minimum densities near transit stations and activity centers.
- Encourage infill development by increasing allowable densities and providing density bonuses in high density residential and commercial zones.

- Implement transfer of development credits programs to allow shifting of development from areas not served by transit to areas near transit stations.

- Provide density bonuses for commercial and office development near transit stations that incorporate desirable design features or public improvements.

- Provide density bonuses to office and commercial projects that include housing.

- Amend zoning ordinance to locate high density residential zones near transit stations and corridors.

- Provide density bonuses for residential developments locating near transit stations.

- Reduce required parking and/or set a maximum parking limit in commercial zones.

- Amend zoning code to require secure bicycle parking at commercial development.

- Amend zoning ordinance to provide neighborhood shops and services within walking distance of residential areas.

- Implement performance zoning system that awards additional points for features such as proximity to transit, on-site shops and services, pedestrian amenities, etc.

- Amend zoning ordinance to prohibit low density, auto-intensive uses near transit.

- Reduce lot size, setback, frontage and/or yard requirements for residential areas.

- Require street trees in all new development and parking lots.

Capital Improvement Program

- Enhance pedestrian environment by funding improvements such as street furniture, landscaping, public art, lighting, etc.

- Fund bicycle trails and construct bicycle lanes in conjunction with road improvements and maintenance.

- Fund shuttle services from major employment sites and activity centers to fixed rail transit stations and ferry terminals.

- Plant and maintain street trees.

- Fund transit service at levels appropriate to density of development.

Subdivision Ordinance

- Require clustering of residential lots, particularly near transit stations and commercial centers.

- Require new residential developments to provide direct and convenient sidewalks and bike lanes/bike paths.

- Revise the subdivision ordinance to require bike lanes on new or modified arterials and/or a system of bike paths.

- Require direct pedestrian/bicycle pathways between residential areas and nearby commercial areas.

- Require new residential subdivisions to provide neighborhood shops and services within walking distance of most homes.

CEQA Review

- Encourage early consultation between project proponents and city/county staff, the Air District and other appropriate agencies to incorporate trip reduction features and other air quality mitigation measures in project design.

- Monitor effectiveness of trip reduction features and other air quality mitigation measures in mitigation monitoring and reporting programs.

Discretionary Permit Processes

- Reduce developer fees and/or expedite review process for mixed use projects which conform to air quality planning principles.

- Require large commercial development to provide on-site services such as child care, postal, restaurants, ATMs, etc.

- Impose housing impact fees on large commercial development to support affordable housing; reduce/waive fees if project includes affordable housing.

- Condition approval of specific plans and large mixed use projects to require phasing of construction to provide residential and commercial development concurrently.

- Consult transit provider early in project review process.

Dust Control Programs/Ordinances

Construction, demolition and grading — require contractor, property owner , and/or operator to:

- assign a dust-control coordinator at the job-site
- minimize surface area disturbed
- limit dusty work on windy days
- apply water, crusting, and/or other dust suppression measures
- clean up dirt/dust spills
- erect dust screens on large buildings in construction or demolition

- water areas of buildings being demolished
- rinse tires/tracks of construction vehicles before exiting construction sites
- cover dirt/dust storage piles

Agricultural Activity

- postpone plowing and other dusty activities on windy days
- postpone pesticide/insecticide/fertilizer spraying or dusting on windy days
- cover piles of dirt, dust, fertilizer
- pave vehicle roads, paths, storage areas

Other Dust-Suppressing Activities

- pave roads, driveways, parking areas and lots
- plant wind breaks, install wind-fences
- apply water or dust suppressant on temporary roads, parking lots
- to the degree feasible, require quarry operators to follow procedures similar to those recommended (above) for construction, demolition and grading.

APPENDIX F: DESIGN STRATEGIES

Appendix F has been published separately by the Association of Bay Area Governments and the Bay Area Air Quality Management District, under the title:

> ***DESIGN STRATEGIES for encouraging alternatives to auto use through local development review***

This appendix is not reproduced in this bound set of appendices. A copy of Appendix F can be obtained from:

ABAG Publications
P.O. Box 2050
Oakland, CA 94604
(510) 464-7900

APPENDIX G: LOCAL AIR QUALITY PLANNING PROCEDURES

This appendix is designed for cities and counties that are interested in including air quality policies and programs in their general plans, and wish to do so by following procedures similar to those suggested in the *General Plan Guidelines* of the State of California Office of Planning and Research (OPR). Even if the locality decides on some variation of the State-recommended process, the principles outlined below would apply.

Key Features

Air quality policies and programs may vary from community to community, depending the location, size, urban/rural characteristics, development status, transportation availability and traffic congestion of the local jurisdiction (see Appendix E, Table E.I), as well as its air quality conditions and emission sources. A city or county where air contaminant emissions are high should consider formulating a detailed air quality element, while a briefer element may be appropriate for a locality with only minor air contaminant emissions.

The specific characteristics and conditions of each community will, of course, determine the final form and content of its air quality element, section, or alternative policy/plan document; nonetheless it is strongly recommended that every city and county in the Bay Area follow at least a common *de minimus* methodology — as outlined below. Using standardized methodology assures that all relevant factors are at least considered in each community and county. An efficient methodology incorporates an early screening process in order to focus attention on the most significant factors in each locality. The screening process should cover several basic components, as outlined in Table G.I.

Developing Air Quality Policies, Plans, and Programs

Table G.I is a more detailed version of the diagram on page 11 of the Guidebook text. The first column of Table G.I lists the essential phases in the process of formulating an air quality element or alternative. The procedures are harmonious with — though not identical to — the eight-step planning process prescribed by the State of California's Office of Planning and Research in its *General Plan Guidelines* (California OPR, 1990). The second column outlines contents of an element which should be addressed (*de minimus* requirements). The third column lists additional components that are important to include but are less critical.

As indicated in Table G.I, effective air quality planning on the local level requires an integrated process. The process should clearly reflect relationships among its phases and with other local general plan elements and regional plans.

Table G.I DEVELOPMENT OF AIR QUALITY POLICIES, PLANS, AND PROGRAMS

PROCEDURAL PHASES	MINIMUM CONTENTS	DESIRABLE COMPONENTS
Analyze AQ-relevant Conditions	meteorology, pollution potential and related background (Appendix D) AQ-relevant development and transportation factors - current and projected (Appendix E) projected emissions of pollutants (Appendix C)	threats to clean air, visibility impairment, special monitoring study of current CO and/or toxic hot spots
Inventory AQ-related Measures	local/regional AQ-related plans, policies, regulations & programs	study feasibility of additional AQ policies and regulations (Checklist and Appendices E & F)
Locate Major Emission Sources	criteria pollutants, toxics, odors, dust	identify potential future sources of airborne contaminants and nuisances
Locate Sensitive Receptors	schools, child care facilities, hospitals, facilities for the elderly	residential areas, playgrounds, parks
Develop Policies & Plans	integrate locally appropriate AQ policies/plans re land-use, transportation, open space, housing, growth control, etc. (Checklist and Appendices E & F)	participate in subregional planning

Table G.I (Continued)

PROCEDURAL PHASES	MINIMUM CONTENTS	DESIRABLE COMPONENTS
Reconcile for Consistency Horizontal	• with local general plan elements, other policies and programs	coordinate with transit providers, relevant special districts
Vertical	• with regional clean air plans • with ABAG projections and regional growth policies, RTP, CMPs	consistency with state, national, and international policies — e.g., reduction of CFCs, CO_2
Adopt and Implement	general plan amendments, ordinances, implement programs AQ aspects of zoning, transit budgets, capital improvement program, etc. (Checklist and Appendices E & F)	locally controllable area source programs — e.g., fireplace/stove wood burning, construction-dust control
Evaluate and Monitor	environmental impacts (CEQA), including cumulative impact of plans in neighboring communities, counties, and the subregion. On-going monitoring system of environmental impacts should be formulated and implemented.	cost-benefit & socioeconomic analyses (Appendix H) and on-going monitoring of impacts (including differential effects on population sectors, if any)

Plan Specificity Beyond General Principles

While each community's general plan is distinct, most plan elements contain general goals as well as more focused policies and programs. The effectiveness of an air quality element, or alternative policy document, will be greatly limited if it does not include specific policies which lead directly to implementable programs. The implementation programs, in turn, should be more specific and, where possible, tied to quantifiable objectives whose achievement or failure can be objectively evaluated. In the ideal situation, programs should be directly tied to existing or realistically predictable budgets.

Subregional Cooperation

Pollutants know no political boundaries; activities in a city or county with relatively clean air may be a source of pollution downwind. Thus, it is important for all cities and counties in nonattainment areas to look for ways to reduce emissions.

Policies that promote subregional air quality planning particularly with respect to motor vehicle emissions are of prime importance. Travel patterns in much of the Bay Area are quite dispersed, with people living, working, shopping, and recreating in myriad locations quite distant from each other. Many suburban destinations are not readily accessible by public transportation. Most local governments, acting independently, can have an impact on reducing auto use and improving air quality. However, local government's ability to reduce dependency on the automobile and increase the viability of transportation alternatives will be greatly enhanced by coordinating land use and circulation policies with neighboring communities.

Subregional cooperation is currently being advanced by ABAG's Regional Planning Committee and by the county and city joint planning promoted by congestion management agencies. These new agencies are mandated by state legislation to focus on traffic congestion and related land use and air quality issues.

Soliciting Public Input

The objective of public participation is to create an atmosphere and process in which conflicting demands for limited community resources can be resolved.

Citizen participation, required under state law, should occur at the following stages of the development of an air quality element or alternative document:

- Identification of major issues and opportunities in the plan
- Identification of community goals that will serve as the foundation of the plan
- Evaluation of alternative plans and participation in choosing the preferred alternative

California OPR General Plan Guidelines Process

Regional Setting Information

Local planners who wish to formulate an air quality element or section in accordance with the eight-step process suggested by the State (California Office of Planning and Research, 1990) should find it useful to begin their analysis with an examination of the background information contained in previous appendices, e.g., air pollution sources and effects (Appendix A); air quality management regulatory background (Appendix B); air quality status, problems and trends (Appendix C) and climatic and related conditions (Appendix D).

The Eight-Step (OPR) Planning Process

Step One: Identifying Issues, Opportunities, and Assumptions Related to Air Quality

Issues:

- Regional air quality issues and relevance to the specific city or county.
- Subregional or countywide air quality issues.
- Local sources of emissions.

Benefits of improving air quality:

- Quality of life (see Appendix H, Tables H.V and H.VI).
- Financial advantages associated with improving air quality (Tables H.III and H.IV).

Assumptions:

- Estimated effectiveness of regional, state and federal air quality protection programs and city/county responsibilities (see Appendix H and references therein).
- Population and economic projections (ABAG *Projections '94* or future editions).

Step Two: Formulating Goals

The overall goal of an air quality element would be to assure that air pollution levels do not threaten public health, safety, or welfare (crops or materials). Goals relating air quality to economic and population growth or other changes should also be included. The goals of an air quality element or local air quality plan would include:

- Regional as well as local air quality goals (i.e., attainment of national and state standards, reduced exposure of individuals to criteria pollutants, toxic air contaminants and odors).

- Air quality goals that are achievable within the confines of the jurisdiction (e.g., reduced emissions from mobile sources through better land use planning).

Step Three: Collecting and Analyzing Data

Local air pollution status, trends, potential, climate and topography (Appendices C and D):

- In order to put air quality planning in context, the air quality element or section should describe historical trends and current conditions at both the local and regional level.
- Regarding local conditions, the air quality element should include the most recent data from the nearest Air District monitoring station or stations. The air quality element should relate monitoring data to attainment of air quality standards. Any violations of air quality standards should be identified. Even if all standards are met locally, the air quality element should discuss how local emissions contribute to the regional ozone problem.

Growth projections, land use, transportation, housing, open space, and other planning concerns which influence air quality:

- Explore the linkage between expected population and economic growth or other change, and air pollutant emissions. (Local government projections of population and employment and the most recent ABAG projections.)
- Estimate future changes in population and demographic characteristics, housing supply, employment and transportation facilities; any differences from ABAG projections should be explained. Future employment should be compared to future housing supply, leading to a calculation of the anticipated jobs/housing balance. By balancing the number of housing units and local employment opportunities, a community can discourage long-distance commute trips and encourage alternatives to the single-occupant vehicle.
- Projections should include estimates of locally employed residents; a numerical balance between jobs and housing does not guarantee that residents will work in local jobs. Employment projections should include some estimates of wage levels. Housing projections should analyze the number of (rental and for-purchase) units by price range in order to determine whether the planned housing stock will be appropriate for local employees, i.e., whether employee incomes will fall in line with housing affordability.

Traffic projections and air quality:

- Future traffic volumes should be estimated based on these growth projections. Traffic projections should estimate total daily trips, peak hour trips, vehicle miles traveled, average speeds on major roads, and congestion (level of service) at heavily traveled roadways and intersections. If possible,

traffic projections should distinguish between trips originating or terminating in the community and through trips.

- Traffic counts for state highways can be obtained from Caltrans. Trip generation data for various land uses can be obtained from MTC and/or from the published reports of Caltrans and the Institute of Transportation Engineers (ITE). Most city and county traffic engineering departments carry out occasional counts of trips, by time of day or trip type, for local roads. Countywide congestion management agencies may become good sources of data.

- For localized CO modeling (CALINE4 modeling), estimates of carbon monoxide concentrations are based on traffic projections. Computer models such as CALINE4 yield reasonably accurate estimates of future CO concentrations. The simplified formula devised by the Air District in its CEQA Guidelines (BAAQMD, 1985) may be used for smaller traffic volumes. CO modeling should include appropriate background values (Appendix C, Figure C.4.a) and should be based on worst-case traffic and meteorological conditions. CO concentrations should be modeled at sensitive receptors near heavily congested intersections and/or roadway links. (Chapter VII of the Air District's CEQA Guidelines explains the CO modeling process in greater detail.)

- Mobile source emissions of criteria pollutants resulting from future growth should be estimated.

Non-mobile source emissions inventory:

- For stationary sources, emissions estimates are available based on land use acreage in the Air District's CEQA Guidelines (BAAQMD, 1985), Table VI - C - 2). If industries using toxic chemicals are located or are anticipated in the community, these emissions should also be estimated. (The Air District's Air Toxics Evaluation Section is available to answer questions on this topic).

- The local air quality plan should list the location and emissions of all major stationary sources in the community. Data concerning the largest stationary sources are listed in the back of the Air District's most recent Air Quality Handbook (BAAQMD, 1993 and subsequent). The air quality element should discuss any potential nuisance sources, such as sewage treatment plants, landfills, gravel pits, and agricultural areas.

Identification of sensitive receptors:

- One of the main reasons for air quality planning and regulation is to protect the most sensitive members of the population. Sensitive receptors include children, the elderly, and those with pre-existing respiratory and circulatory conditions. The term "sensitive receptors" can also refer to the land use categories where the sensitive receptors live or spend a significant amount of time. Such land uses include residences, schools, playgrounds, child care centers, hospitals,

retirement homes, and convalescent homes.

- The local air quality plan should list these land uses and map their location. Such an inventory is essential to guide local land use and air quality planning to assure that sensitive population groups are not exposed to elevated concentrations of air pollutants.

Identification of existing commitments and policy constraints, on the local level:

- Explicitly identify constraints which limit achievement of goals (e.g., pre-existing permits for low density land uses near transit centers).

Step Four: Determining Objectives

- Articulate regional as well as local air quality objectives.
- Identify intermediate program objectives to meet a specified air quality goal (e.g., prepare a redevelopment plan for higher density, "transit-oriented" development (TOD) within walking distance of a transit center).
- Establish quantified and time-specific requirements associated with air quality objectives (e.g., aim for a specific percent reduction in emissions from a given source by a given date).

Step Five: Developing and Evaluating Alternative Plans

While each community must develop its own set of policy statements, the following discussion is intended to review some very minimum issues to be addressed in an evaluation of alternative air quality policies. Their applicability will vary depending on local conditions. For example, a city that does not contain nor expect the development of stationary air pollutant sources need not adopt air quality policies regarding such sources.

- All local air quality plans should address the cumulative impacts of development to the degree these are known or can be estimated. All local air quality policies should also include directives concerning mobile sources. At the very least, the chosen policies and plans should guarantee that traffic will not cause local exceedences of air quality standards. In choosing the most appropriate alternative among policies studied, preference should be given to those that address the impact of local traffic on regional air quality.
- Air quality policies should be cross-referenced with relevant policies from other appropriate plan elements. The air quality element or section should be explicit about how policies of various general plan elements influence travel patterns and air quality.

Step Six: Selecting and Adopting the Preferred Plan

- Establish criteria to evaluate the preferred alternative. Evaluate each alternative — quantitatively if appropriate, but at least qualitatively — for its probable effect on local and regional air quality.

- Optimize among conflicting objectives — e.g., high densities around transit centers are usually preferred vis-a-vis air quality but may not be appropriate if adjoining uses generate large amounts of toxic air contaminants and/or odors.
- Choose the plan or set of policies that best achieve overall community and regional goals, including air quality goals.

Step Seven: Implementing the General Plan

A local air quality plan is only as strong as its implementation strategies. Within the Bay Area local general plans vary greatly with respect to implementation. Local government's ability to affect air quality derives mainly from its powers to regulate land use and transportation; this translates into implementation tools such as zoning, capital improvements and operating programs. The size, type and location of development will obviously affect traffic conditions and air quality. Cities and counties can influence air quality by establishing requirements in such programs and activities as development controls, road building, infrastructure provision, and support of affordable housing.

- Local governments can also lead by example. For instance, a comprehensive trip reduction program for municipal and/or county employees could be a demonstration for the private sector in the community. Other examples of local government leadership include using fuel-efficient or alternative-fuel vehicles. (Implementation programs to reduce mobile source emissions are outlined in the Checklist in the Guidebook and in Appendix E).
- The actions of numerous players besides local governments can directly or indirectly influence air quality. These include federal, state and special district agencies. Other actors include private employers, real estate developers, and lending institutions who may resist programs unless the local government itself provides leadership.

Step Eight: Monitoring Implementation and Amending the General Plan

Monitoring implementation:

- Government Code Section 65400(b) requires the planning agency to "Provide an annual report to the legislative body on the status of the plan and progress in its implementation."
- For the air quality element or section to be effective, there must be some means of assessing performance. Policies should be specific and implementation programs should include specific performance standards.
- Perhaps the most obvious method of evaluating performance is air quality monitoring data. (Local governments should regularly review data from the nearest Air District monitoring station to assess current air quality conditions.) Progress in implementing air quality policies can be better evaluated, however, if implementing programs

include numerical goals. Examples of such goals include a percentage reduction in drive-alone vehicle trips; a specific number of units of low/moderate income housing; or total vehicle miles traveled.

Amending the general plan:

- "Portions of the general plan with a short-term focus, such as the implementation program, should be reviewed annually and revised as necessary to reflect the availability of new implementation tools, changes in funding source, and the results of monitoring the effectiveness of past decisions.....As a general rule, major plan revisions should occur at least every four to five years" (California Office of Planning and Research, 1990).
- The air quality element or section may require even more frequent updates, however, based upon state requirements to update the regional Clean Air Plan every three years.
- Air quality planning is subject to change. Some issues, such as toxic air contaminants or indoor air pollutants, are receiving more attention today than in the past. The form and content of a local air quality plan should be amenable to subsequent changes in local conditions and/or regional plans.
- California Government Code Section 65352 establishes a review period for a proposed general plan or amendment by, among others, regional planning agencies. The Air District would have 45 days to comment on the Air Quality Element under this provision.

Potential Linkages Between an Air Quality Element and Other Elements of a Local General Plan

As stressed throughout the Guidebook and these appendices, the requirement for consistency among planning policies and programs is a primary reason for formulating an air quality element or section in the local general plan. Listed below are some of the major planning and implementation measures to be considered for achieving a variety of community goals in addition to benefiting air quality. (See also Appendix E for additional measures and greater detail.)

Mandatory General Plan Elements

Land Use Element

- mixed uses (services and employment sites proximate to residential)
- density — residential and work-place density (for support of transit)
- compatibility for sensitive uses (separation of noxious uses from sensitive receptors)
- locational criteria (trip generators served by transit)

Circulation/Transportation Element

- TCM program, including parking strategies (see Appendix F)
- CMP integration (see Appendix F)
- RTP and TIP consistency
- site design to minimize auto dependency
- transportation aspects of TODs

Housing Element

- jobs/housing balance
- affordability to workers at proximate sites

Conservation Element

- integrated (intermedia) environmental protection programs
- tree planting programs
- energy conservation programs
- waste management programs

Open Space Element

- buffer zones
- infill policy
- urban-growth boundaries
- open space preservation and creation

Safety Element

- separation of sensitive receptors from toxics, nuisances
- emergency plans for predicted incident days/periods

Other Planning-Related Issues and Implementation Programs

Dust Control Program, Grading Ordinances

(see Appendix E)

Community Design Standards and Controls

(see Appendix F — separate publication)

CEQA Review and Related Processes

CMP and Other TCM/TDM programs

(see Appendix E)

Zoning Ordinance

- *minimum* residential and work-place density
- require mixed uses such as service facilities in residential and work-place areas

Subdivision Ordinance

- transit/pedestrian-bicycle-friendly features

Business Licenses

Enterprise Zones, Empowerment Zones, and Other Neighborhood-Based Improvement Programs

Capital Improvement Program

Redevelopment

- realize opportunities to rebuild at higher densities near transit stations
- mix uses to minimize necessity of motor vehicle use

Economic Development

Energy Conservation Program

Building And Housing Codes and Code-Enforcement Activities

LAFCO Activities and Urban-Growth Boundaries

Opportunities for Subregional Planning and Program Cooperation

Growth-Management Measures

APPENDIX H: BENEFITS AND COSTS OF LOCAL AIR QUALITY PROGRAMS

This appendix addresses some key questions about air quality planning: How much air quality benefit can be expected from integration of air quality policies and programs into the local planning process? What are the costs and/or problems associated with programs aimed at reducing the use of motor vehicles and the air contaminant emissions they generate? What are the likely impacts of air quality measures on achievement of other community goals; and the obverse: what will be the effects on air quality of various community programs aimed at other objectives? Answers to these questions are attempted in the following information and tables.

The data in this appendix are presented in quantitative form where available — i.e. in terms of reductions in air contaminants, usage of various transportation forms, monetary costs and benefits, or number of jobs affected; where quantification is not feasible, qualitative estimates are given.

Reductions In Motor Vehicle Usage And Emissions

Table H.I estimates air contaminant reduction associated with specific planning actions that are usually under the jurisdiction of cities or counties. Table H.II estimates impacts of selected measures on transportation variables, e.g., mode split, auto ownership, etc. This information provides indications of how such measures may impact motor vehicle emissions.

Tables H.I and H.II address land use measures. Tables H.III and H.IV include evaluations of the costs and benefits of transportation measures, land use measures and stationary source (industrial) measures adopted in the Bay Area '91 Clean Air Plan.

It should be noted that the ability to estimate costs and air quality and other benefits is still inexact, especially as applied to transportation control measures (TCMs) and indirect source measures. A number of field studies and syntheses of empirical and theoretical explorations have been undertaken or are currently being conducted. Selected findings of completed studies, including those conducted in the Bay Area, are excerpted and cited in the discussion and tables of this appendix.

Following are a few highlights — and cautions — related to the research and expert opinion cited in the tables.

Many measures, especially those related to land use, require a number of years, or even decades, before the full benefits to the region are realized. Thus the estimated benefits of TCMs within the Bay Area '91 Clean Air Plan, for a five year period between 1992 and 1997, indicate very modest benefits. For example, zoning for higher densities near transit is estimated to produce .05% reduction in emissions for the region as a whole by the year 1997 (Harvey & Deakin, 1991). Yet, there are indications of much more significant longer-range potential if this urban design principle is widely extended.

A representative of a developer reported that new residents, in at least one development located and designed for proximity to a major transit station, drive much less than average Bay Area residents. In this higher-density mixed land use project, adjoining the El Cerrito Del Norte BART station, 40% of residents do not own automobiles; 50% ride BART to work; 71% use BART for non-commute trips (Frasleur, 1993).

Another analysis of the correlation between density and travel behavior in the Bay Area includes an estimate of air contaminant reductions: "Compared to the average Danville — San Ramon [low-density] resident, the average Nob Hill [San Francisco] resident emitted 5 kilograms (11 pounds) less hydrocarbons, 12 kg less nitrogen oxides...and 104 kg less carbon monoxide [per day]" (Holtzclaw, 1990).

A study for Portland, Oregon differentiated the effects of mixed use from that of density. It concluded: "If strict land use homogeneity was [sic] eliminated and land uses were allowed to mix, the number of vehicle trips per person in suburbia could be cut by 18%-25%, even if development densities were not increased." (Bartholomew, 1993).

A study in southern California estimated that growth management — with a major emphasis on jobs/housing balance — could reduce 18% of automobile and light-duty truck emissions by the year 2010 (Planning Center, 1990).

Table H.I POTENTIAL AIR QUALITY BENEFITS OF PLANNING MEASURES

BAY AREA STUDY (Harvey/Deakin, 1991)				
PLANNING MEASURES	*PROJECT BENEFIT — reduction in criteria contaminants compared to conventional developments*			
• Transit-oriented developments (TODs) and similar standards of transit access, design, density, land-use mix	10% to 30% (informal estimate by consultant)			
	REGIONAL BENEFIT — reduction in criteria contaminants compared to current trends			
• Mandatory indirect source control (ISC) regulations applicable to new and existing indirect sources				
year 2005-2010	up to 10% (informal estimate by consultant)			
1992-1997	0.7%			
LOS ANGELES AREA STUDY (South Coast AQMD, 1993)				
PLANNING MEASURES	*PROJECT BENEFITS — reduction in criteria contaminants compared to conventional developments*			
	ROG	*NOx*	*CO*	*PM_{10}*
• Residential units within commercial project	3-14%	4-18%	4-18%	4-18%
• Bus turnouts, benches, shelters	up to 2%	3%	3%	3%
• Reduce parking spaces at commercial sites	up to 2%	2%	2%	2%
• On-site employee services, e.g., cafeterias, banks	up to 3%	5%	5%	5%
• Child-care & after-school facilities, on-site or near work	up to 0.1%	0.2%	0.2%	0.2%
SAN BERNARDINO COUNTY-CITIES STUDY (The Planning Center, 1990)				
PLANNING MEASURE	*REGIONAL BENEFITS — reduction in criteria contaminants compared to current trends*			
	ROG	*NOx*	*CO*	*PM_{10}*
• Jobs-Housing Balance (by 2010)	4%	3%	10%	0.2%

Table H.II EFFECTS OF DENSITY AND LAND USE MIX ON TRAVEL BEHAVIOR

PORTLAND, OREGON STUDIES (Cambridge Systematics and Calthorpe Associates, 1993)

Benefits of transit/infill/high-density "LUTRAQ" development scenario — compared to projections of conventional development alternatives which would extend or exacerbate the existing trends toward suburbanization and lower densities. ("LUTRAQ" is an acronym for: Land Use, Transportation, Air Quality)

	BENEFIT TO REGION — by year 2010
Share of commute trips by transit	+ 45%
Proportion of all trips by foot or by bicycle	+ 22%
Households owning 2-3 automobiles	- 6%
Vehicle trips per household	- 8%

	BENEFIT TO RESIDENTS OF THE TRANSIT-ORIENTED DEVELOPMENTS (TOD)
Average auto ownership per household	- 11%
Average home-based trips in auto	- 22%
Commute by transit	+227%
Proportion walking to work	+120%
Children walking or biking to school	+100%

SHOPPING CENTERS — COMPARATIVE TRIP ANALYSIS STUDY (JHK & Associates and K.T. Analytics, 1993)

Comparison of trips to four suburban and one central business district shopping sites (some in the Bay Area). The shopping centers vary by density, freeway accessibility, parking charges, transit service, and amenities for bicycles and pedestrians. The trip statistics cited are comparisons according the most salient variable: density.

	PERCENT OF TRIPS BY MODE		
	Suburban		Central Business District
Travel Mode:	Low-density	High-density	
Auto	91–95%	57%	38%
Transit	4–6%	21%	33%
Walk	1–2%	22%	29%

Socioeconomic Impacts of the Bay Area '91 Clean Air Plan (CAP)

Table H.III is taken from the *Socioeconomic Report for the '91 CAP*, specifically from the volume: *Response to Comments* (BAAQMD, by Applied Development Economics, October 1991). It summarizes costs as well as benefits of implementing measures to improve air quality, differentiated by those sectors of the region thought to be most impacted by the CAP: business and industry, commuters, low-income groups, and governments (local, regional, state and federal).

The table shows which impacts have been quantified in terms of either annual dollar amounts or number of jobs. For unquantified impacts, the table indicates whether the effects are generally beneficial or negative by the number of (+) or (-) signs in each entry.

The measures noted in Table H.III as "Social Transfers" are those that are transfers of revenue within society to achieve the purposes of cleaner air quality — e.g. parking fees at job sites, paid by workers who commute in single-occupancy-vehicles and transferred to those who carpool, vanpool, or take public transportation. These measures do not represent added costs to society as a whole. Thus, although such measures may increase the costs of travel to some, the revenues also constitute benefits for other Bay Area residents and/or businesses.

Cost and Effectiveness of Employer-Based Trip Reduction Programs

Table H.IV addresses cost ranges and effectiveness of employer-based trip reduction programs, mainly in qualitative terms. It also provides comments on such issues as whether or not a particular measure or program is likely to pay for itself, the degree of controversy that might be generated, and the estimated impact on the Vehicle Employee Ratio (VER) — a performance measurement developed as a useful alternative to Average Vehicle Ridership (AVR). The table is excerpted from the Air District's *Guide to Employee Trip Reduction Programs* (BAAQMD, November 1993).

Table H.III Summary Of Socioeconomic Impacts Of The CAP

CAP MEASURES	AFFECTED GROUPS							
	Business and Industry		Commuters		Low Income Groups		Bay Area Government	
TRANSPORTATION CONTROL MEASURE	Benefits	Costs	Benefits	Costs	Benefits	Costs	Benefits	Costs
Employer-Based Trip Reduction (TCMs 1,2)								
Highway Travel Time Savings	$10.7 M		$108.5M		(++)		(++)	
Administrative Cost		$150 M						$5 M
Employee Parking Fees (ST)				$1,460 M		(– – –)		
Mobility Improvements, Traffic Operation Management, Transit User Incentives (TCMs 3-15)								
Highway Travel Time Savings	$26.3 M		$266.3 M		(++)		(++)	
Construction Employment (10 yrs)	25,000 jobs				(++)			
Transit Opera. Perm. Employ.	2,880 jobs				(++)			
Indirect Perm. Employment	6,450 jobs				(++)			
Implementation Costs								$598 M
Driver Expenses (ST)		$22.3 M		$203.6 M				
Indirect Source Review (TCM 16)								
Highway Travel Time Savings	$4.5 M		$45.5 M		(++)		(++)	
Administrative Costs								$12 M
Development Costs		(– –)						
Implementation Support (TCMs 17-21)								
Highway Travel Time Savings	$8.4 M		$85.1 M		(++)			
Administrative Costs								$4 M
Increased Housing Production	(+)		(+)				(+)	
Market-Based Measures (TCM 22)								
Highway Travel Time Savings	$112 M		$1,100 M		(++)		(++)	
Driver Expenses (ST)		$332.4 M		$3,000 M		(– – –)		(– – –)

Note: All dollar figures are annual benefits or costs expressed in 1991 dollars

M = million. ST = Social Transfer

Table H.III (Continued)

CAP MEASURES	AFFECTED GROUPS							
	Business and Industry		Commuters		Low Income Groups		Bay Area Government	
STATIONARY SOURCE CONTROL MEASURES	Benefits	Costs	Benefits	Costs	Benefits	Costs	Benefits	Costs
Compliance Costs								
Maximum Total Costs		$339.8 M						(– –)
Major Industry Costs								
General Manufacturing		$102.1 M						
Utility Industries		$115.4 M						
Petroleum Refining		$76.9 M						
Restaurants		$13.2 M						
Transportation Equipment		$8.3 M						
Concrete and Glass Mfg		$6.6 M						
Employment Losses Due to Combined Compliance Costs								
Directly Related Perm Jobs				2,160 jobs		(– –)		
Indirect/Induced Perm. Jobs				8,970 jobs		(– –)		
Employment Gains From Control Technologies								
Directly Related Perm. Jobs			1,080 jobs		(++)			
Indirect/Induced Perm. Jobs			4,490 jobs		(++)			
GENERAL CAP IMPACTS								
Health Benefits								
Reduced Health Costs	(++)		(++)		(++)		(++)	
Slower Health Services Employment Growth				(–)		(–)		
Increased Worker Productivity	(++)						(++)	
Increased Agricultural Production								
Lower Prices					(+)			
Increased Employment			(+)					
Other Impacts								
Fuel Savings	(++)		(++)		(++)		(++)	
Increased Travel Time on Transit		(– –)		(– –)		(– –)		(– –)
Reduced Materials Deterioration	(++)		(++)		(++)		(++)	
Increased Property Values	(++)		(++)				(++)	
Improved Quality of Life	(++)		(++)		(++)		(++)	

Note: All dollar figures are annual benefits or costs expressed in 1991 dollars. M = Million

Table H.IV TRIP REDUCTION PROGRAM MEASURES – Summary

Program Measure	Cost Range	Comments/Effectiveness
1. Marketing	Varies substantially. Principal costs related to staff time and media/materials used. Could be costly if upscale promotion with external expertise is funded.	Essential element of any program. Determines effectiveness of all other measures.
2. Ridematching	Public ridematching services are free. In-house ridematching can be performed at very low cost.	Essential element. Most effective when implemented in conjunction with related measures.
3. Preferential Parking	Generally low or no-cost.	Provides visible support for ridesharing. Effectiveness depends upon the work site and available parking.
4. Guaranteed Ride Home	Generally low cost. Cost per use may be high, but frequency of use is usually very low.	Considered essential program element to relieve employee anxiety over using a commute alternative.
5. Transit Information and Ticket Sales	Minimal. Some staff time. Transit route maps/schedules are free. Providing vouchers through Commuter Check™ will increase costs.	Very effective when work site is well-served by transit.
6. Incentives	Varies substantially depending upon the subsidy/reward offered.	Highly effective. Provides tangible evidence of employer's commitment to commute alternatives.
7. Transportation Allowance	Can be funded by parking fees. Costs would vary depending upon the level of the allowance and the parking fee.	Highly effective in improving VER when coupled with parking fees. Mitigates employee resistance to parking pricing.
8. Parking Pricing	Pays for itself. Revenues can fund other trip reduction measures.	Single most effective measure to improve VER. Potentially controversial if not designed and implemented with sensitivity, equity, and return.
9. Vanpool Assistance	Varies depending upon approach. Can be structured on a cost recovery basis.	Very effective in improving VER, given the right conditions. Vanpools are most cost-effective for long commutes--one-way distance of 20 plus miles.

VER = Vehicle Employee Ratio; ratio of vehicle trips to peak period employees at a worksite

Table H.IV (Continued)

Program Measure	Cost Range	Comments/Effectiveness
10. Compressed Work Week	Low. Only administrative costs to set up and run the program.	Very effective means to improve VER by up to 20 percent. Popular with employees. Experience indicates that CWW has no negative impact on employee productivity.
11. Home-Based Telecommuting	Varies depending upon program design. Costs are minimal if employee procures equipment.	Can be very effective if significant number of employees can telecommute one or two days per week. Popular with employees.
12. Bicycle Parking	Varies from $50 to $750 per space, plus installation costs.	Very effective when many employees live within five miles of the site; assuming access to the site is safe.
13. Showers and Clothes Lockers	Averages $60,000–$85,000.	See comments (#12) above.
14. Support for Bicyclists and Walkers	Minimal, depending upon the support provided.	Can include route maps, mentor program, special recognition or promotion. See comments (#12) above.
15. Shuttles to Transit	Varies substantially from $30,000–$300,000 annually. Costs can be shared with other employers, government grants.	Can be effective when work site is located within 3 miles of a rail station.
16. Midday Shuttles	Varies substantially. Costs can be reduced if combined with shuttles to transit (#15).	Effectiveness in improving VER is indirect; i.e. may eliminate reason for employees to have own car at the work site.
17. On-Site Services	Varies depending upon service. Can be very low if outside vendors provide the service. Can be revenue producer depending on structure.	Effectiveness in improving VER is indirect; i.e. may eliminate reason for employees to have own car at the work site.
18. Site Modifications	Varies substantially depending upon the improvement. Improvements likely to have other benefits.	Can be very effective if improvements improve access and entice shift to transit or non-motorized modes.
19. Clean Fuel Vehicles	Cash subsidies and refueling/recharging facilities can be expensive. Preferential parking for clean fuel vehicles is low cost.	Effectiveness in improving VER is high only if a substantial number of employees commute in clean fuel vehicles.
20. Housing	Varies depending upon the incentive offered. Costs can be significant. Minimal cost to distribute housing information.	Could be effective if linked to commute alternative use and a large number of employees participate. Most commonly provided in response to work site relocation.

VER = Vehicle Employee Ratio; ratio of vehicle trips to peak period employees at a worksite

Complementary Benefits

Many efforts to improve air quality provide other environmental and quality-of-life benefits for cities, counties, and the region as a whole. Some of these complementary benefits are outlined in Table H.V. On the other hand, a number of community and regional objectives regarding land use, transportation, housing, and open space can have a positive effect on air quality. Table H.VI is a short list of some of the community and regional development patterns and transportation features that would have the most significant long-term beneficial impacts on air quality. (See also Appendices E and F for much more detailed information on city and county planning measures which would benefit local and regional air quality.)

Table H.V Other Benefits of Local Air Quality Measures

Development patterns and transportation systems that benefit air quality would also usually produce:

- reduced traffic congestion.
- increased mobility.
- reduced consumption of energy, fuel and other natural resources.
- more efficient use of infrastructure and land resources.
- more cohesive communities.
- improved water quality (reduced runoff and contamination).
- preservation of regional open space, agriculture, the Bay, wetlands, parks and recreational areas, and other amenities.
- reduced roadway construction and maintenance.
- reduced air contaminants and other chemicals which are implicated in environmental problems such as global warming, acid deposition, stratospheric ozone depletion, and toxic contamination.

Table H.VI Development Patterns And Transportation Systems Beneficial To Air Quality

- mixed land uses — residences, workplaces and services located to minimize the need for private motorized transportation.
- housing affordable to the workers in nearby workplaces.
- development within stable urban growth limits — emphasizing infill projects and minimizing auto-dependent sprawl.
- public transportation reasonably priced with superior service and wide area coverage.
- residential and workplace densities high enough to support a viable, cost-effective public transportation system.
- population and workforce diversity throughout urbanized areas minimizing long commutes for all sectors of the population.

GLOSSARY

Abatement — the reduction in degree or intensity, or elimination, of pollution.

Acid Deposition — conversion of sulfur oxide and nitrogen oxide emissions into acidic compounds which precipitate in rain, snow, fog, or dry particles.

Adverse Health Effects — health effects from exposure to air contaminants that may range from relatively mild temporary conditions, such as minor eye or throat irritation, shortness of breath, or headaches, to permanent and serious conditions such as birth defects, cancer, or damage to lungs, nerves, liver, heart, or other organs.

Aerosol — particle of solid or liquid matter that can remain suspended in the air because of its small size (generally under one micron).

Air — so-called pure air is a mixture of gases containing about 78 percent nitrogen; 21 percent oxygen; less than 1 percent of carbon dioxide, argon, and other inert gases; and varying amounts of water vapor.

Air and Waste Management Association (AWMA) — a national society of persons interested in air pollution control and waste management.

Air Basins — areas defined by geographical or administrative boundaries; used for air pollution control programs.

Air Monitoring — sampling for and measuring of pollutants present in the atmosphere.

Air Quality Criteria — the varying amounts of pollution and lengths of exposure at which specific adverse effects to health and comfort take place.

Air Quality Management District (AQMD) — local agency charged with controlling air pollution and attaining air quality standards. The Bay Area Air Quality Management District is the regional AQMD that includes all of seven counties (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo and Santa Clara) and the southern halves of Solano and Sonoma Counties.

Air Quality Standard (AQS) — the prescribed level of a pollutant in the outside air that cannot be exceeded during a specific time in a specified geographical area. Standards are established separately by federal and California state governments. Therefore national and state standards differ concerning some pollutants.

Air Resources Board (ARB) — the State of California agency responsible for air pollution control.

Airshed — a term denoting a geographical area the whole of which, because of topography, meteorology, and climate, shares the same air (see Air Basins).

Ambient Air — outside air; any portion of the atmosphere not confined by four walls and a roof.

Aromatic — an unsaturated organic compound with a ring structure. Example: benzene.

Asbestos — a mineral fiber that can pollute air or water and cause cancer or asbestosis when inhaled. EPA has banned or severely restricted its use in manufacturing and construction.

Association of Bay Area Governments (ABAG) — a voluntary joint-powers comprehensive regional planning agency for the nine Bay Area counties.

Asthma — illness that causes abnormal restriction of breathing; outbreak may be precipitated in response to allergens or air contaminants.

Authority to Construct (A/C) — a preconstruction permit issued by an AQMD.

Banking — a provision in Air District permit regulations where a facility can take credit for reducing emissions beyond regulatory limits and use that credit at a later date. Similar to a savings account that does not pay interest.

Best Available Control Technology (BACT) — an emission limitation based on the maximum degree of emission reduction which is achievable through application of production processes and available methods, systems, and techniques.

California Clean Air Act (CCAA) — legislation enacted in 1988 mandating a planning process to attain state ambient air quality standards.

Carbon Dioxide (CO_2) — a colorless, odorless, non-poisonous gas, which results from fossil fuel combustion and is normally a part of the ambient air.

Carbon Monoxide (CO) — a colorless, odorless, toxic gas produced by the incomplete combustion of carbon-containing substances. One of the major air pollutants, it is emitted in large quantities by exhaust of gasoline-powered vehicles.

Carcinogen — any substance that can cause or contribute to the production of cancer.

Catalytic Converter — an air pollution abatement device used primarily on motor vehicles. It removes organic contaminants by oxidizing them into carbon dioxide and water through chemical reaction. May convert nitrogen dioxide to nitrogen and oxygen, as well as promoting other similar reactions.

Chlorofluorocarbons (CFCs) — a family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere they drift into the upper atmosphere where their chlorine components destroy stratospheric ozone.

Chronic — marked by long duration or frequent recurrence, as a chronic disease.

Clean Air Act (CAA) — long-standing federal legislation, last amended in 1990, that is the legal basis for the national clean air programs.

Coefficient of Haze (COH) — a measurement of the quantity of dust and smoke in the atmosphere in a theoretical 1000 linear feet of air. A COH of less than 1 is considered clean air and more than 3 is considered dirty air.

Conformity — a concept in federal law and administrative practice that requires that projects will only be approved if they do not jeopardize specified planning goals, including air quality management goals.

Congestion Management Agency (CMA) — a county-wide agency, required under state law in California. The CMA boards include representatives of the incorporated cities within the county as well as representatives of the county government. A major purpose is to monitor road conditions and to attain and maintain an acceptable Level of Service.

Congestion Management Program (CMP) — a program which must be prepared and undated biennially by each CMA.

Consistency Among Plans and Programs

Horizontal: consistency among sections or elements of plans/programs of a single local government, e.g.: between the Land-Use Element, Circulation Element and Air Quality Element or Section of a city or county's General Plan.

Vertical: consistency among the plans/programs of different levels of government agencies with responsibilities to each other, e.g. consistency of all aspects of a local general plan with the regional air quality plan, CMP, Regional Transportation Plan, etc.

Depth: consistency among plans and implementation programs, e.g. between the Land-Use Element of a General Plan and the Zoning Ordinance, Capital Improvements Program, etc. of the same city or county.

Criteria Air Pollutants — as required by the 1970 amendments to the Clean Air Act, the EPA identified and set standards to protect human health and welfare for six pollutants: ozone, carbon monoxide, total suspended particulates, sulfur dioxide, lead, and nitrogen oxide. The total suspended particulate standard has since been changed to a more health-oriented PM_{10} standard. The term "criteria pollutants" derives from the requirement that the EPA must describe the characteristics and potential health and welfare effects of these pollutants. It is on the basis of these criteria that standards are set or revised.

Dew Point — the temperature at which droplets of water condense from air (dependent on the prevailing humidity).

Dust — solid particulate matter that can become airborne.

Ecology — the interrelationship of organisms and their environment, and the science that is concerned with that interrelationship.

Electrostatic Precipitator — an air pollution abatement device that removes particulate matter from a gas stream by imparting an electrical charge to the particles for mechanical collection on an electrode.

Emission Factor — the amount of a specific pollutant emitted from a specified polluting source per unit quantity of material handled, processed, or burned. By using the emission factor of a pollutant and specific data regarding quantities of material used by a given source, it is possible to compute emissions for the source and, cumulatively, to prepare an emissions inventory.

Emission Inventory — a list of air pollutants emitted into an area's atmosphere, in amounts (commonly tons) per day or year, by type of source.

Emission Standard — the maximum amount of pollutant that is permitted by regulation to be discharged from a polluting source.

Environmental Protection Agency (EPA) — the federal agency responsible for control of air and water pollution, toxic substances, solid waste, and cleanup of contaminated sites.

Ethanol — ethyl alcohol, a volatile alcohol containing two carbons (CH_3CH_2OH). For fuel use, it would be produced by fermentation of corn or other plant products, with any water being distilled away.

Exceedance — a monitored level or concentration of any air contaminant higher than national or state ambient air quality standards.

Flexible Fuel Vehicle — vehicle that can use either alcohol fuels (methanol or ethanol) or unleaded gasoline, or any combination of the two.

Fluorides — compounds containing fluorine; emitted into the air from a number of industrial processes; fluorides are a major cause of vegetation and, indirectly, livestock damage.

Fluorocarbon — an organic compound that contains fluorine. Some of these compounds may affect health but they are not smog forming.

Fossil Fuels — coal, oil, and natural gas; so-called because they are the remains of ancient plant and animal life.

Greenhouse Effect (or **Global Warming**) — the warming of the earth's atmosphere — and/or other significant, long-term changes in regional climates — caused by a build-up of carbon dioxide and other trace gases. This build-up allows light from the sun's rays to heat the earth but prevents a counterbalancing loss of heat.

Ground Level Monitor (GLM) — a type of air pollution monitoring device located around major industrial facilities to measure ambient levels of certain pollutants.

Hazardous Air Pollutants — air pollutants which are not covered by ambient air quality standards but which may reasonably be expected to cause or contribute to serious illness or death (see NESHAPS).

Health Risk — an estimate of the probability that exposure to a given set of toxic air contaminants will result in an adverse health effect. The health risk is affected by several factors: the amount and toxicity of emissions, the weather, distance from sources to people, the distance between sources, the age, health and lifestyle of the people living and working at the receptor location. The term "risk" usually refers to the increased chance of contracting cancer as a result of an exposure, and is expressed as a probability: chances-in-a-million.

Health Risk Assessment — a document that identifies the risks and quantities of possible adverse health effects which may result from exposure to emissions of toxic air contaminants. A health risk assessment cannot predict specific health effects; it only describes the increased possibility of adverse health effects, based on the best scientific information available.

Hot Spot — a location where emissions from specific sources may expose individuals and population groups to elevated risks of adverse health effects, including but not limited to cancer, and contribute to the cumulative health risks of emissions from other sources in the area.

Hydrocarbon — any of a vast family of compounds containing carbon and hydrogen in various combinations; found especially in fossil fuels. Some of the hydrocarbon compounds are major air pollutants; they may be active participants in the photochemical process or affect health.

Hydrogen Sulfide (H_2S) — a gas characterized by "rotten egg" smell, found in the vicinity of oil refineries, chemical plants and sewage treatment plants.

Indirect Sources — land-uses and facilities which do not, in themselves, emit significant amounts of contaminants, but which attract or generate a large volume of motor vehicle trips and consequent emissions, e.g.: shopping centers, office buildings and complexes, sports facilities, large housing developments.

Indirect Source Review/Control — measures which are applied, by local government or regional agencies, to minimize the use of the private automobile.

Inversion — the phenomenon of a layer of warm air over cooler air below. A special problem in polluted areas because this atmospheric structure resists the natural dispersion and dilution of air contaminants.

Level of Service (LOS) — A transportation planning term for a method of measurement of congestion. The LOS compares actual or projected traffic volume to the maximum capacity of the road under study. LOS ranges from A through F. LOS F describes the most congested conditions, up to or over the maximum capacity for which the road was designed. Except in a few instances LOS E is the standard established in the Congestion Management Programs of the Bay Area's nine countywide Congestion Management Agencies. Some CMAs have established LOS D as the standard for facilities in undeveloped and rural areas.

Methanol — the simplest (or single carbon) alcohol, generally produced from natural gas (methane).

Metropolitan Transportation Commission (MTC) — the local agency that provides comprehensive regional transportation planning for the Bay Area and distributes federal and state transportation assistance funds.

Micro — a prefix meaning 1/1,000,000 abbreviated by the Greek letter μ (mu)

Micron — a unit of length equal to one thousandth of a millimeter or about 1/25,000 of an inch

Milli — a prefix meaning 1/1,000

Mist — liquid particles up to 100 microns in diameter.

Mixing Depth — the expanse in which air rises from the earth and mixes with the air above it until it meets air equal or warmer in temperature — the inversion cap.

Mobile Source — a moving producer of air pollution, mainly forms of transportation such as cars, trucks, motorcycles, airplanes.

National Ambient Air Quality Standards (NAAQS) — health-based pollutant concentration limits established by EPA that apply to outside air (see Criteria Air Pollutants).

National Emissions Standards for Hazardous Air Pollutants (NESHAPS) — emissions standards set by EPA for air pollutants not covered by NAAQS that may cause an increase in deaths or in serious, irreversible, or incapacitating illness.

Nitric Oxide (NO) — precursor of ozone, nitrogen dioxide (NO_2), and nitrate; usually emitted from combustion processes. It is converted to NO_2 in the atmosphere, which then becomes involved in the photochemical process of ozone generation and/or particulate formation.

Nitrogen Oxides (NOx) — gases formed in great part from atmospheric nitrogen and oxygen when combustion takes place under conditions of high temperature and high pressure; NOx is a criteria air pollutant.

Non-Attainment Area — defined geographic area that does not meet one or more of the Ambient Air Quality Standards for the criteria pollutants designated in the federal Clean Air Act and/or California Clean Air Act.

Non-Attainment Area Plan — a plan developed by the Air District for the purpose of meeting an air quality standard.

Opacity — degree of obscuration of light. For example, a clear window is "0" in opacity, a wall is 100% opaque. The Ringelmann system of evaluating smoke density is based on opacity; 20% opacity = Ringelmann 1.

Open Burning — the uncontrolled burning of waste materials in the open, in outdoor incinerators, or in an open dump either intentionally or accidentally.

Organic Compounds — large group of chemical compounds that contain carbon. All living organisms are made up of organic compounds. Some types of organic gases, including olefins, aromatics and aldehydes, are highly reactive — that is, participate in photochemical reactions in the atmosphere to form oxidant.

Oxidant — air pollutants containing oxygen that can react chemically with other substances. In the ambient air, oxidant is mostly ozone, plus small quantities of nitrogen compounds.

Ozone (O_3) — a pungent, colorless, toxic gas. A product of complex photochemical processes, usually in the presence of sunlight; tropospheric (ground-level and lower atmosphere) ozone is a criteria air pollutant.

Ozone Depletion — destruction of the stratospheric ozone layer (10 to 20 miles above the earth) which shields the earth from ultraviolet radiation. This destruction is caused by the breakdown of certain chlorine and/or bromine-containing compounds (chlorofluorocarbons or halons).

Particulate — a particle of solid or liquid matter; soot, dust, aerosols, fumes and mists.

Parts Per Million (ppm) — the number of parts of a given pollutant in a million parts of air. One ppm equals .0001% .

Permit to Operate (P/O) — an operational permit issued yearly by the Air District to industrial sources which emit air contaminants..

Photochemical Process — the chemical changes brought about by the radiant energy of the sun acting upon various polluting substances. The products are known as photochemical smog.

Pollution Standards Index (PSI) — a national, standardized system of reporting air pollution levels to the public by assigning them a numerical value.

PM_{10} — fine particulate matter (solid or liquid) with an aerodynamic diameter equal to or less than 10 microns. Individual particles of this size are small enough to be inhaled into human lungs; they are not visible to the human eye.

Plume — a visible or measurable discharge of an air contaminant from a given point of origin. For example, a plume of smoke.

Precipitators — any of a number of devices using mechanical, electrical, or chemical means to collect particulates. Used for measurement, analysis, or control.

Precursor — compounds that change chemically or physically after being emitted into the air and eventually produce air pollutants. For example, organic compounds are precursors for ozone.

Prevention of Significant Deterioration (PSD) — EPA program in which state and/or federal permits are required that are intended to restrict emissions for new or modified sources in places where air quality is already better than required to meet primary and secondary ambient air quality standards.

Radon — a colorless, naturally occurring, radioactive, inert gaseous element formed by radioactive decay of radium atoms in soil or rocks.

Reactive Organic Gases (ROG) — classes of organic compounds, especially olefins, substituted aromatics and aldehydes, that react more rapidly in the atmosphere to form photochemical smog or ozone.

Reasonable Further Progress (RFP) — specified rate of progress towards meeting an air quality standard, as set forth in law or plan.

Smog — a term used to describe many air pollution problems, it is a contraction of the words smoke and fog; in California, it is used to describe the irritating summer haze resulting from the sun's effect on pollutants in the air, including those from automobile exhaust.

Soot — very fine carbon particles that appear black when visible.

State Implementation Plan (SIP) — EPA-approved state plans for the attaining and maintaining air quality standards.

Stationary Source — a fixed, non-mobile producer of pollution, usually at industrial or commercial facilities.

Stratosphere — the portion of the atmosphere that is 10-25 miles above the earth's surface.

Sulfur Oxides (SO_x) — pungent, colorless gases formed primarily by the combustion of sulfur-containing fossil fuels, especially coal and oil. Considered a criteria air pollutant, sulfur oxides may damage the respiratory tract as well as vegetation. .

Total Suspended Particulate Matter (TSP) — particles of solid or liquid matter — soot, dust, aerosols, fumes and mist — up to approximately 30 microns in size. As a criteria pollutant TSP has been replaced by PM_{10}.

Toxic Air Pollutants — air pollutants which cause illness or death in relatively small quantities. Non-criteria air contaminants that, upon exposure, ingestion, inhalation, or assimilation into organisms either directly from the environment or indirectly by ingestion through food chains, will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, or physical deformations in such organisms or their offspring.

Transportation Control Measures (TCMs) — measures to reduce congestion and decrease emissions from motor vehicles by reducing vehicle use.

Volatile Organic Compound (VOC) — an organic compound that evaporates readily at normal temperatures; a precursor to ozone.

Wood-Burning Stove and Fireplace Pollution — air pollution caused by emissions of particulate matter, carbon monoxide, and odorous and toxic substances from wood-burning stoves and fireplaces.

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